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MEMOIRS

OF THE

AMERICAN ACADEMY

OF

ARTS

AND

SCIENCES:

TO THE END OF THE YEAR M,DCC,LXXXIII.

VOLUME I.

BOSTON:
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PREFACE.

MANKIND have ever found a ſtate of ſociety ſubſervient to their comfort and happineſs. Subjected to many wants, they have been able, by an union one with another, to obtain that ſupply, which would have been impracticable if each individual had ſtood alone; and invariable experience has taught, that the ſocial bond is the greateſt ſecurity againſt the numberleſs dangers and difficulties, to which they are expoſed. Hence the many political or civil inſtitutions, that have been formed in the world, which have been greater or leſs bleſſings to the perſons, who have belonged to them, in proportion as thoſe inſtitutions have been framed with more or leſs wiſdom, and the members of them have been more or leſs virtuous and prudent.

Societies for promoting uſeful knowledge may be highly advantageous to the communities, in which they are inſtituted. Men united together, and frequently meeting for the purpoſe of advancing the ſciences, the arts, agriculture, manufactures and commerce, may oftentimes ſuggeſt ſuch hints to one another, as may be improved to important ends: and ſuch ſocieties, by being the repoſitories of the obſervations and diſcoveries of the learned and ingenious, may, from time to time, furniſh the world with uſeful publications, which might otherwiſe be loſt: for men of ingenuity, and modeſty, may not chuſe to riſk their reputation, by ſending abroad, unpatronized, what a learned ſociety might judge richly worthy the public eye; or, perhaps, their circumſtances being ſtraitened, they may not be able to defray the expence of publication. Societies inſtituted for promoting knowledge, may alſo be of eminent ſervice, by exciting a ſpirit of emulation, and enkindling thoſe ſparks of genius, which otherwiſe might forever have been concealed; and if, when poſſeſſed of funds ſufficient for the purpoſe, they reward the exertions of the induſtrious and enterpriſing, with pecuniary premiums or honorary medals, many important experiments and uſeful diſcoveries will be made, from which, the public may reap the higheſt advantages.

Eminent inſtances of the beneficial effects of ſuch inſtitutions we have, in the Royal Academy of Sciences at *Paris*, the Royal Society, and the Society inſtituted for the encouragement of Arts,

Manufactures

Manufactures and Commerce, in *London*, and many others of a similar kind, in *Europe*. Hereby a spirit of discovery and improvement has been excited among the ingenious, in almost every nation, in that quarter of the world; and knowledge of various kinds, and greatly useful to mankind, has taken place of the dry and uninteresting speculations of schoolmen; and bold and erroneous hypothesis has been obliged to give way to demonstrative experiment. In short, since the establishment of these societies, solid learning and philosophy have more increased, than they had done for many centuries before.

But the spirit of promoting knowledge, by instituting literary societies, has not been confined to *Europe*: It has found its way to *America*. Some years ago, a number of gentlemen in *Philadelphia*, voluntarily formed themselves into a society, by the title of, The *American* Philosophical Society. They have published one volume of transactions, which has done them honor.

In this Commonwealth, a society for promoting useful knowledge was, for many years, in contemplation; but the design was never vigorously engaged in and pursued, 'till the end of the year 1779, when many gentlemen, persuaded of the utility of such an institution, determined, without delay, to use their endeavors, to have one formed upon a liberal and extensive plan, and at the same time, to have it established upon a firm basis, by obtaining the sanction of the Legislature. And to the honor of our political Fathers be it spoken, that although the country was engaged in a distressing war, a war the most important to the liberties of mankind, that was ever undertaken by any people, and which required the utmost attention of those, who were entrusted with our public concerns, they immediately adverted to the usefulness of the design, entered into its spirit, and incorporated a society, with ample privileges, by the name of, *The American Academy of Arts and Sciences.* The purpose of this institution is to promote most branches of knowledge advantageous to a community, as will appear, by the following charter of incorporation, which was granted May 4, 1780.

"An ACT to incorporate and establish a Society for the cultivation and promotion of Arts and Sciences."

"*AS the Arts and Sciences are the foundation and support of agriculture, manufactures, and commerce; as they are necessary to the wealth, peace, independence and happiness of a people; as they essentially promote the honor and dignity of the government which patronises them; and*

as

" *as they are most effectually cultivated, and diffused through a State,* " *by the forming and incorporating of men of genius and learning into* " *public societies: For these beneficial purposes,*

" *Be it therefore enacted by the Council and House of Representatives in* " *General Court assembled, and by the authority of the same,* That the " Hon. *Samuel Adams*, Esq; Hon. *John Adams*, Esq; *John Bacon*, " Esq; Hon. *James Bowdoin*, Esq; Rev. *Charles Chauncy*, D. D. Rev. " *John Clark*, *David Cobb*, Esq; Rev. *Samuel Cooper*, D. D. Hon. " *Thomas Cushing*, Esq; Hon. *Nathan Cushing*, Esq; Hon. *William Cushing*, Esq; *Tristram Dalton*, Esq; Hon. *Francis Dana*, Esq; Rev. " *Samuel Deane*, Rev. *Perez Fobes*, Rev. *Caleb Gannett*, Hon. *Henry* " *Gardner*, Esq; Mr. *Benjamin Guild*, Hon. *John Hancock*, Esq; Hon. " *Joseph Hawley*, Esq; *Edward Augustus Holyoke*, Esq; Dr. *Ebenezer* " *Hunt*, *Jonathan Jackson*, Esq; Dr. *Charles Jarvis*, Rev. *Samuel* " *Langdon*, D. D. Hon. *Levi Lincoln*, Esq; Rev. *Daniel Little*, Rev. " *Elijah Lothrop*, *John Lowell*, Esq; Rev. *Samuel Mather*, D. D. *Samuel* " *Moody*, Esq; Hon. *Andrew Oliver*, Esq; Dr. *Joseph Orne*, Dr. " *Theodore Parsons*, Hon. *George Partridge*, Esq; Hon. *Robert Treat* " *Paine*, Esq; Rev. *Phillips Payson*, *Samuel Phillips*, jun. Esq; Hon. " *John Pickering*, Esq; Hon. *Oliver Prescot*, Esq; Rev. *Zedekiah* " *Sanger*, Hon. *Nathaniel Peaslee Serjeant*, Esq; *Micajah Sawyer*, Esq; " *Theodore Sedgwick*, Esq; Hon. *William Sever*, Esq; *Stephen Sewall*, " Esq; Hon. *David Sewall*, Esq; *John Sprague*, Esq; *Ebenezer Storer*, " Esq; *Caleb Strong*, Esq; Hon. *James Sullivan*, Esq; Dr. *John Bernard* " *Sweat*, Mr. *Nathaniel Tracy*, *Cotton Tufts*, Esq; Hon. *James Warren*, " Esq; Rev. *Samuel West*, Rev. *Edward Wigglesworth*, Rev. *Joseph* " *Willard*, Rev. *Samuel Williams*, Rev. *Abraham Williams*, Rev. *Nehemiah* " *Williams*, and Mr. *James Winthrop*, be, and they hereby are formed " into, constituted and made a Body Politic and Corporate, by the " name of THE AMERICAN ACADEMY OF ARTS AND SCIENCES; " and that they and their successors, and such other persons as " shall be elected in the manner hereafter mentioned, shall be, and " continue a Body Politic and Corporate, by the same name forever.

" *And be it further enacted by the authority aforesaid,* That " the Fellows of the said Academy may from time to time " elect a President, one or more Vice Presidents, one or more " Secretaries, and such other Officers of the said Academy, as they " shall judge necessary or convenient; and they shall have full " power and authority from time to time to determine and esta- " blish the names, number and duties, of their several officers, and " the tenure or estate they shall respectively have in their offices; " and also to authorize and impower their President, or some

" other

" other Fellow of the Academy, at their pleaſure, to adminiſter " ſuch oaths to ſuch officers as they ſhall appoint and determine, " for the well ordering and good government of the ſaid Academy: " provided the ſame be not repugnant to the laws of this State.

" *And be further enacted by the authority aforeſaid*, That the Fellows " of the ſaid Academy ſhall have one common ſeal, which they " may make uſe of in whatſoever cauſe or buſineſs ſhall concern " the Academy, or be relative to the end and deſign of its inſtitu-" tion; and ſhall have power and authority from time to time " to break, change, and renew the common ſeal, at their pleaſure; " and that they may ſue and be ſued in all actions, real, perſonal " and mixed, and proſecute and defend the ſame unto final judg-" ment and execution, by the name of, The Preſident and " Fellows of the *American* Academy of Arts and Sciences.

" *And be it further enacted by the authority aforeſaid*, That the " Fellows of the ſaid Academy may from time to time elect ſuch " perſons to be Fellows thereof, as they ſhall judge proper; and " that they ſhall have full power and authority from time to time, " to ſuſpend, expel or disfranchiſe, any Fellow of the ſaid Acade-" my, who ſhall by his conduct render himſelf unworthy of a " place in that body, in the judgment of the Academy; and alſo " to ſettle and eſtabliſh the rules, forms and conditions of election, " ſuſpenſion, expulſion and disfranchiſement. *Provided*, That the " number of the ſaid Academy, who are inhabitants of this State, " ſhall not, at any one time, be more than two hundred, nor leſs " than forty.

" *And be it further enacted by the authority aforeſaid*, That the Fel-" lows of the ſaid Academy ſhall have full power and authority " from time to time, to make and enact ſuch reaſonable rules, or-" ders and bye-laws, not repugnant to the laws of this State, as " ſhall be neceſſary or convenient for the well ordering and good " government of the ſaid Academy; and to annex reaſonable pe-" cuniary fines and penalties to the breach of them, not exceeding " the ſum of *twenty pounds*, to be ſued for and recovered in any " Court of record within this State, in the name and for the uſe " of the Preſident and Fellows of the ſaid Academy; and the " ſame rules, orders and bye-laws to repeal at their pleaſure: And " alſo to ſettle and eſtabliſh the times, places, and manner of con-" vening the Fellows of the ſaid Academy: And alſo to deter-" mine the number of Fellows which ſhall be preſent, to conſti-" tute a meeting of the ſaid Academy. *Provided*, That the Fel-" lows of the ſaid Academy ſhall meet twice in a year at the leaſt;

" and

" and that the place of their meeting ſhall never be more than " thirty miles diſtant from the town of *Boſton*.

" *And be it further enacted by the authority aforeſaid*, That the Fel- " lows of the ſaid Academy may, and ſhall forever hereafter be " deemed capable in the law of having, holding, and taking in " fee-ſimple, or any leſs eſtate, by gift, grant, deviſe or otherwiſe, " any lands, tenements, or other eſtate, real and perſonal: *Provided*, " That the annual income, of the ſaid real eſtate, ſhall not exceed " the ſum of *five hundred pounds*, and the annual income or intereſt " of the ſaid perſonal eſtate ſhall not exceed the ſum of *two thouſand* " *pounds*. All the ſums aforementioned in this act to be valued in " ſilver, at the rate of *ſix ſhillings and eight-pence* by the ounce. And " the annual intereſt and income of the ſaid real and perſonal eſtate, " together with the fines and penalties aforeſaid, ſhall be appro- " priated for premiums to encourage improvements and diſco- " veries in agriculture, arts and manufactures, or for other pur- " poſes, conſiſtent with the end and deſign of the inſtitution of the " ſaid Academy, as the Fellows thereof ſhall determine.

" *And be it further enacted by the authority aforeſaid*, That the " end and deſign of the inſtitution of the ſaid Academy is, to pro- " mote and encourage the knowledge of the antiquities of *America*, " and of the natural hiſtory of the country, and to determine the " uſes to which the various natural productions of the country " may be applied; to promote and encourage medical diſcoveries, " mathematical diſquiſitions, philoſophical enquiries and experi- " ments; aſtronomical, meteorological and geographical obſerva- " vations; and improvements in agriculture, arts, manufactures " and commerce; and in fine, to cultivate every art and ſcience, " which may tend to advance the intereſt, honor, dignity and " happineſs of a free, independent and virtuous people.

" *And it is further enacted*, That the place where the firſt meeting " of the Fellows of the ſaid Academy ſhall be held, ſhall be the " Philoſophy Chamber in the Univerſity of *Cambridge*; and that the " Honorable *James Bowdoin*, Eſq; be, and he hereby is authoriſed " and empowered to fix the time for holding the ſaid meeting, " and to notify the ſame to the Fellows of the Academy."

Such is the baſis, upon which this inſtitution is placed.

Not many months after this act of incorporation was paſſed, the ſtatutes were formed, the body became organized, and communications were received. From the communications till the end of the year 1783, the following volume is now offered to the public.

This

This country being young, and few among us having ſuch affluence and leiſure as to admit of their applying much time to the cultivation of the ſciences, and to the making of improvements in arts, manufactures, agriculture, &c. it will not, at preſent, be expected, that this Academy ſhould vie with ſimilar inſtitutions in old countries, where they have peculiar advantages for ſuch proſecutions. Yet, it is hoped, that the following papers will not be reckoned uſeleſs, nor prove unacceptable to the public.

The aſtronomical and mathematical papers, in this volume, will, perhaps, be the leaſt entertaining of any in the collection, and will have the ſmalleſt number of readers. However, they are uſeful in ſuch a work. Few, if any of them, contain deep ſpeculations and obſtruſe reſearches and calculations; but they are chiefly of the practical kind. The aſtronomical pieces principally exhibit ſuch obſervations and deductions, as are ſubſervient to the cauſe of geography and navigation, the improvement of which is of great importance to this country. And as aſtronomical obſervations may be applied to ends ſo valuable, it is earneſtly to be wiſhed, that every gentleman capable of it, would improve every opportunity to make them with accuracy, and when made, would kindly communicate them to the Academy. Theſe, and all mathematical pieces, will be gratefully received, and due attention paid to them, by this body.

To ſome readers, the ſubject of many papers, which have a place in the phyſical part, may ſeem unimportant; but it ought to be remembered, that one intereſting purſuit of the Academy is the natural hiſtory of their own country;—a country, where the arts of defence and the means of ſubſiſtence have, hitherto, almoſt engroſſed the induſtry of its inhabitants; where the foſſil and vegetable kingdoms are yet unexplored, and perhaps, their moſt valuable productions ſtill undiſcovered.

It is the part of a patriot-philoſopher to purſue every hint—to cultivate every enquiry, which may eventually tend to the ſecurity and welfare of his fellow citizens, the extenſion of their commerce, and the improvement of thoſe arts, which adorn and embelliſh life. Nor can ſuch traces and veſtiges, as may occur, of the manners and reſources of its aboriginal inhabitants, be unworthy the collection. Beſides the idea thus excited of the condition of man in ſavage life, the preſent inhabitants of the ſame climate and ſoil may thereby, in ſome way or other, occaſionally receive hints, which may be improved to their own advantage. This principle, which has govern-

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ed the Academy in making the selection, will account for the introduction of some articles, relating to the natural history of the country.

Many pursuits, in various branches of natural philosophy, are retarded, by the difficulty of obtaining that variety of instruments, which can be had only from those countries, where the manufactures, which minister to the arts, are established in perfection. But this difficulty, it is hoped, will daily lessen, and ere long, entirely cease.

The medical papers may, probably, contain many observations not entirely new. However, this ought not to be considered a sufficient objection to their being inserted in this work, because many important discoveries in pathology, as well as in the animal œconomy, have been in a great measure useless to this part of the world, in consequence of a situation so remote from ancient seats of learning and improvement. And of such publications as have reached this country, the smallness of the number has greatly limited their usefulness, as but few have had opportunity for perusing them. In points merely speculative, this inconvenience has been less consequential; but, in practical science, deeply to be regretted. A long war, in which these States were engaged, destroyed, for a time, that intercourse, by means of which, books on the various arts and sciences, and such as contained the most modern discoveries and improvements, had usually been obtained. The contents of some of these papers, therefore, though they may afford nothing new to the *European*, yet, to many *American* readers may have the recommendation of novelty.

It may be further remarked, that although the novelty of an opinion or discovery may, sometimes, more advance the fame and honour of the author, yet, that there are known facts, of such a nature, that the repetition of them, in publications of this kind, may be no less useful to the world, as they may thereby be more forcibly impressed upon the mind, and conveniently adverted to, in common practice.

Upon these principles the Academy conceived it to be their indispensible duty to publish, by means best adapted to the purpose of diffusing their utility, such experiments and observations, as, though not new, yet, not having been sufficiently attended to, may be more extensively applied towards perfecting the present modes of practice in this country, as well as to communicate, by the earliest opportunities, such discoveries, as may lead to the investigation of important phenomena, in the animal œconomy.

It is obvious that the following work is well calculated for anſwering theſe intentions. The circulation of it will be principally confined to theſe States; and as a repoſitory of miſcellaneous papers on the ſubject of phyſic and ſurgery, it will, doubtleſs, generally fall into the hands of gentlemen of the faculty in this country; a circumſtance, which will very rarely take place, with reſpect to any publication imported from abroad.

The Members of the Academy are diſpoſed to do every thing in their power to promote the deſigns of the inſtitution; but they are ſenſible, that much aid is wanted from others; and they are happy to have it in their power to acquaint the public, that from the number of valuable communications, which have been made by gentlemen in various parts of the country, there is reaſon to expect, that their aſſiſtance will be continued, and ſuch materials furniſhed, as will not be unworthy the notice of the public, which it is the ſincere wiſh of the Academy to ſerve. And from that expectation, and the great encouragement given to the printing of this volume, they have the pleaſing proſpect, that they ſhall be able to publiſh a ſucceſſion of volumes. The papers they now have in their hands will go a conſiderable way towards another; and they doubt not, they ſhall ſoon have ſufficient to complete it.

There is now an ample field opened, in this country, in which the ingenious may expatiate; and men of various turns of mind may employ their leiſure, not only to their own amuſement and improvement, but alſo to the emolument of the community.

Agriculture ſtands in great need of attention. As the ſolid proſperity of the country will much depend upon the cultivation of our lands, too much regard cannot be paid to this ſubject. To examine the various ſoils, and determine what each is beſt adapted to produce; to aſcertain the moſt ſuitable manures, and the means of increaſing them; to deviſe methods to ſecure the fruits of the field, and of the trees from blights and deſtructive inſects, will afford a fine opportunity for experiments, which, it is hoped, will engage the minds of the curious and inquiſitive, and meet with encouragement from gentlemen of property.

The genius for natural hiſtory may have a large range, as the foſſil, the vegetable and animal kingdoms, in this part of the world, lie before him.

There will be ample room for the reſearches of the Botaniſt and Chymiſt, who, while they purſue their reſpective branches, may greatly contribute to the advancement of the healing art, which is of the higheſt importance to the inhabitants of a country.

The

The labors of the Astronomer are much needed, and will be peculiarly useful,—particularly those observations and calculations, which will serve to perfect the geography of the country, and improve navigation, as has before been intimated. Hereby, the boundaries between one State and another in the Union, may be accurately determined, and disputes prevented or settled; the latitudes and longitudes of our sea-ports and head lands ascertained, and our intercourse with foreign nations facilitated.

The various mechanical arts and manufactures, together with commerce, require peculiar attention and cultivation; and much may be expected, from that spirit of enterprise, which our citizens are known to possess. Happily, they who are engaged in these several branches of business may mutually aid each other; and every improvement they make, will tend to enrich and aggrandize these confederated States.

But this preface would far exceed the proper limits, should all those branches of business and of science be pointed out, which ought to be attended to and cultivated, by the inhabitants of these States. Let it only be added, that, settled in an extensive country, bordering upon the ocean, and open to a free intercourse with all the commercial world—A country comprehending several climates and a rich variety of soils, watered and fertilized by a multitude of springs and streams, and by many grand rivers, some of them admitting of a fine inland navigation,—the citizens have great opportunities and advantages for making useful experiments and improvements, whereby the interest and happiness of the rising empire may be essentially advanced. At the same time, enjoying, under a mild but steady government, that freedom, which excites and rewards industry, and gives a relish to life—That freedom which is propitious to the diffusion of knowledge, which expands the mind, and engages it to noble and generous pursuits,—they have a stimulus to enterprise, which the inhabitants of few other countries can feel. May they ever be as virtuous and industrious as they are free! May a spirit for advancing every kind of knowledge, that can redound to their honor, and promote the emolument and happiness of themselves and their country, more and more prevail! And may all their laudable endeavors, to further the good of mankind, be crowned with success adequate to their highest wishes!

November 16, 1785.

STATUTES

OF THE

AMERICAN ACADEMY OF ARTS AND SCIENCES.

CHAPTER I.

Of Officers, and the manner of their election.

1. THERE ſhall be a Preſident, one Vice-Preſident, ten Counſellors, two Secretaries, a Treaſurer, a Vice-Treaſurer, and a Keeper of the Cabinet: which officers ſhall be annually elected by written votes on the day next preceding the laſt Wedneſday in May.

2. In order to this election, the Preſident, or in his abſence the Vice-Preſident, or in the abſence of the Preſident and Vice-Preſident, the ſenior Counſellor preſent ſhall take the chair, at three o'clock, P. M. and after the choice of three ſcrutineers by nomination, the ballot ſhall begin and remain open till five o'clock, at which time it ſhall be cloſed; upon which, ſhould it appear in any inſtance that there is no choice, the balloting ſhall be renewed till a choice is made.

3. Each Elector ſhall deliver his balloting liſt, folded, to the Preſident, and a ſcrutineer, ſitting by the Preſident with a liſt of the Members of the Academy preſent before him, ſhall mark the name of each perſon ſo delivering in his liſt.

4. When the ballot is cloſed, the ſcrutineer ſhall ſort the votes, and report the ſame to the chair; after which, the preſiding member ſhall declare the perſons, who have the majority of votes, to be the officers reſpectively for the enſuing year.

5. If either of the Secretaries, the Treaſurer, or the Keeper of the Cabinet die, reſign, or be removed during the year, at the next meeting of the Academy the vacant office or offices ſhall be filled by written votes for the remaining part of the year.

6. At

6. At all elections of officers, if the suffrages should be equal, the decision shall be by lots prepared by the scrutineers, and drawn by the President.

7. Notwithstanding the election of officers be annual, the Academy reserve to themselves a power of removing any of them for neglect of their trust, or disobedience to the orders of the Academy.

8. A Messenger may be appointed or removed at any meeting of the Academy.

CHAP. II.

Of the President and Vice-President.

1. THE business of the President, or in his absence of the Vice-President, or in the absence of the President and Vice-President, then of the senior Counsellor present, shall be to preside in the meetings, and to regulate the debates of the Academy and Council; to state and put questions both in the affirmative and negative, according to motions regularly made; to call for reports and accounts from Committees and others; to preserve decorum; to summon all meetings of the Council, and all extraordinary meetings of the Academy, by advice of Council, upon any urgent occasions; and to execute or to see to the execution of the statutes of the Academy.

2. The President, or in his absence the Vice-President or presiding Counsellor, is empowered to draw upon the Treasurer for such sums of money as the Academy shall direct.

CHAP. III.

Of the Council.

1. THE Council shall have full authority, and it is their incumbent duty, from time to time, to originate such laws, statutes, orders and constitutions, as shall appear to them to be necessary or useful, according to their judgment and discretion, for the regulation, government, and promotion of the design of the Academy: all which laws, statutes, orders and constitutions, shall be by them presented at a meeting of the Academy for the approbation of the Fellows; also to prepare such other matters as they may judge proper to be pursued by the Academy, in order to advance in the best manner the end of its institution. Nevertheless, no Fellow is

hereby

hereby precluded from laying before the Academy ſuch matters, or propoſing ſuch laws, as he ſhall think conducive to its benefit.

2. The Council, with the Preſident and Treaſurer, have power to make concluſive bargains for real or perſonal eſtate, for the benefit of the Academy, and to rent the ſame, and to give orders concerning the improvement of the eſtate, goods, lands and revenues of the Academy, purſuant to the orders of the Academy.

3. Every deed or writing to which the common ſeal is to be affixed, ſhall be paſſed and ſealed in Council, and ſigned by the Preſident, and four, at the leaſt, of the Council.

4. During the receſſes of the Academy, the Council ſhall direct the Secretaries in ſuch correſpondence as they ſhall find expedient. The whole of which ſhall be laid before the Academy at its next meeting.

5. The Council ſhall order ſuch papers and letters to be recorded as they ſhall think proper.

CHAP. IV.

Of the Secretaries.

1. ONE of the Secretaries ſhall have the charge and cuſtody of the Charter and Statute-Book, Journal-Books, Regiſter-Books, and all literary papers belonging to the Academy; and alſo all letters, after they have been recorded, ſhall be kept by him on file. This Secretary, if poſſible, ſhall attend at all meetings of the Academy and Council, where, when the preſiding member hath taken the chair, he ſhall read the orders and entries of the laſt precedent meeting, and ſhall take notes of the orders and tranſactions of the preſent meeting, to be entered by him in the reſpective books, to which they relate. And when there ſhall be a competent number for making elections, he ſhall give notice of any candidates that ſhall ſtand propounded in order to election into the Academy.

2. The other Secretary ſhall have the charge and cuſtody of the letter-books belonging to the Academy. He ſhall attend all meetings of the Academy and Council, and read all letters ſent to the Academy, or to any member in his academical capacity, and draw up all letters to be written to any perſons in the name of the Academy or Council (to be read and approved of in ſome meeting of either, reſpectively) except for ſome particular cauſe and conſideration, ſome other perſon or perſons be appointed by the Academy or

or Council, to draught any ſuch letter. He ſhall alſo enter all letters that ſhall be directed by the Academy or the Council, and when entered, the originals ſhall be delivered to the firſt-mentioned Secretary in order to their being filed.

3. At every meeting of the Academy, the Secretary, in whoſe cuſtody the letter-books are, ſhall read any entries that the preſiding member ſhall direct; and the Secretary, in whoſe cuſtody the originals are, ſhall have with him, ready to produce, the file of all letters received ſince the laſt precedent meeting, that, if it be required, a compariſon may be made.

4. Each Secretary ſhall deliver an atteſted copy of any tranſaction of the Academy, or paper belonging to his particular department, to any member, upon his producing a written licence from the Council for that purpoſe; and to any other perſon, who ſhall produce a licence from the Academy ſigned by the preſiding member, and in no other caſe whatever.

5. Whenever any copy ſhall be delivered by a Secretary, the perſon, upon receiving it, ſhall pay him ſuch fees as the Academy may eſtabliſh.

CHAP. V.

Of the Treaſurer and Vice-Treaſurer.

1. THE Treaſurer and Vice-Treaſurer ſhall give ſuch ſecurity as the Academy ſhall require for the truſt repoſed in them reſpectively.

2. The Treaſurer ſhall receive officially all monies or ſums of money due or payable, and all bequeſts and donations that may be made to the Academy: and by order of the Preſident or preſiding member, ſhall pay ſuch ſums as the Academy or the Council ſhall direct, purſuant to the orders of the Academy, and ſhall make no diſburſements of money otherwiſe, and ſhall keep a particular account of ſuch orders, receipts, and payments.

3. All monies or ſums of money whereof there ſhall not be preſent occaſion for expending, or diſpoſing to the uſe of the Academy, ſhall be put out to intereſt on ſuch ſecurities, or otherwiſe diſpoſed of as the Academy, or the Preſident and Council, purſuant to the orders of the Academy, ſhall direct.

4. The Treaſurer's accounts ſhall be annually audited by a Committee appointed by the Academy for that purpoſe. In which appointment not more than one member of the Council ſhall be included.

5. In

5. In caſe of the death, reſignation or removal of the Treaſurer, the Vice-Treaſurer is empowered to receive all books, papers, and effects, that were in the cuſtody of the Treaſurer, and which belong to the Academy, and to give receipts and diſcharges for the ſame in the name of the Academy. A duplicate of which ſigned by the Vice-Treaſurer ſhall be filed with the Preſident. The ſame proceſs ſhall be obſerved upon the choice of a new Treaſurer, and his acceptance of the office.

CHAP. VI.

Of the Keeper of the Cabinet.

1. THE Keeper of the Cabinet ſhall receive and have in his charge and cuſtody, all productions of nature and works of art, that ſhall be purchaſed by, or preſented to the Academy. He ſhall arrange them according to their reſpective claſſes in natural hiſtory, philoſophy, &c. at his own diſcretion; unleſs he be directed therein by a Committee of the Academy for that purpoſe. He ſhall alſo, in a book, to be kept by him, regiſter the various articles in claſſes correſponding to the arrangement of the Articles themſelves, with the deſcription that may accompany the article, the donor's name, and the place whence taken; and the time when preſented.

2. He ſhall attend the exhibitions of the articles in his cuſtody, whenever the Academy ſhall meet; and no perſon ſhall be admitted to a view of them at any other time, unleſs in preſence of the Keeper of the Cabinet, or ſome member appointed by the Council for that purpoſe.

3. He ſhall be Librarian to the Academy 'till they ſhall judge it expedient to appoint a diſtinct perſon to that office.

4. He ſhall give ſuch ſecurity as the Academy ſhall judge proper for the faithful diſcharge of his office, and for ſurrendering the articles in his cuſtody, whenever required by the Academy.

CHAP. VII.

Of the Meetings of the Academy and Council.

1. THERE ſhall annually be four ſtated meetings of the Academy, viz. On the laſt Wedneſday in *January*, and the day next preceding the laſt Wedneſday in *May*, at *Boſton*, and on the Wedneſday

Wednesday next preceding the last Tuesday in *August*, and the second Wednesday in *November* at the University in *Cambridge*. Provided that in case the President shall at either of the said annual meetings, within the year of his first appointment, think proper to deliver, before the Academy, an inaugural oration or philosophical discourse, the place of such meeting may be at *Boston* or *Cambridge*, according as it shall be most convenient to him: of which he shall give notice at some preceding meeting of the Academy.—The Council shall also meet four times annually, viz. On the first Wednesday in *January*, and the first Wednesday in *May*, at *Boston*; and on the first Wednesday in *August*, and the third Wednesday in *October*, at *Cambridge*: unless it should by any means be unsafe for the Academy or Council to convene at either of the places above-mentioned, at the times specified. In which case the President with the advice of the Council, may appoint the next stated meeting of the Academy, at any place within thirty miles distance from *Boston*; and the President in the abovementioned case may appoint a meeting of the Council within the above said limits.

2. Extraordinary meetings of the Academy may be called at any time or place within thirty miles distance from *Boston*, by the President with the advice of the Council. And extraordinary meetings of the Council may be called by the President within the aforesaid limits, whenever he shall judge it necessary.

3. Eleven Fellows shall be present to constitute a meeting of the Academy, unless for the purposes of receiving communications, and adjourning, in which cases, seven shall be a quorum. And at any meeting of the Council the presiding member, with four others of the Council, are required to be present, in order to transact any business proper to the Council.

4. At all meetings of the Academy or Council the President, and Vice-President, or in their absence, the presiding member shall have a right to vote in common with the other members of either body respectively.

5. No person shall be introduced to any meeting of the Academy but by vote of the Academy, except *American* and foreign Ambassadors, members of Congress, members of the Supreme Legislative and Executive of the State of *Massachusetts* for the time being, and members of similar institutions with this Academy, who may be introduced by any member of the Academy.

6. All meetings of the Academy ſhall be advertiſed in two at leaſt of the public news-papers, fourteen days previous to ſuch meeting, by one of the Secretaries under direction of the Preſident, or in his abſence of the Vice-Preſident, or preſiding member of the Council.

7. All meetings of the Council ſhall be notified to the ſeveral members by billets from the Preſident, or one of the Secretaries under direction of the Preſident, or in his abſence, of the Vice-Preſident or preſiding member of the Council, ſeven days at leaſt, before the time ſtated or propoſed for a meeting.

CHAP. VIII.

Of Fellows.

1. NO perſon ſhall be elected a Fellow of the Academy, unleſs propoſed and recommended by one or more of the members, nor nominated to the Academy until he has firſt been propoſed to the Council, and they have conſented to ſuch nomination; and the name, place of abode, and addition of the perſon recommended, ſhall be delivered in, ſigned by the propoſers, and read by one of the Secretaries. A fair copy of ſuch paper, with the date when delivered, ſhall be hung up in the room, where the Academy ſhall from time to time meet, on which the Candidates may be balloted for at the next, or ſome ſucceeding meeting. And if three-fourths of the Fellows then preſent ſhall ballot in his favor, he ſhall be a member.

2. Each Fellow reſiding in the State of *Maſſachuſetts*, ſhall be ſubject to an annual payment of *Spaniſh* milled dollars in ſpecie, or an equivalent in bills of the current exchange. Fellows without the State ſhall be ſubject to no other annual payment, than they voluntarily conſent to.

CHAP. IX.

Of Proceedings on literary Performances.

1. THE Academy will never give their judgment or opinion, upon any literary performances preſented to them, but allow it to reſt upon its own merit, and the credit of its author.

CHAP.

CHAP. X.

Of Oaths.

1. THE Preſident, Vice-Preſident, Counſellors, Secretaries, Treaſurer, Vice-Treaſurer and Keeper of the Cabinet, ſhall each take the following oath, *mutatis mutandis* :

> I A. B. *elected to the office of*   *in the* American Academy of Arts and Sciences, *do ſwear, that I will, according to my beſt judgment and diſcretion, faithfully diſcharge the duties of the truſt repoſed in me.*
>
> So help me GOD.

An Explanation of the Plate in the title Page.

THE principal figure in it is Minerva. At her right-hand is a field of Indian Corn, the native grain of *America.* The proſpect on that ſide is bounded by an hill, crowned with Oaks. On the declivity of the hill, towards the ſea, appears the out-ſkirt of a town, the body of which is concealed by the hill. About the feet of Minerva are ſcattered ſeveral inſtruments of huſbandry. On her left-hand are a quadrant and a teleſcope, a proſpect of the ſea, with a ſhip ſteering towards the town ; and the ſun riſing, and appearing compleatly above the cloud, in which it roſe. Over the whole, the motto SUB LIBERTATE FLORENT.

The device repreſents the ſituation of a new country, depending principally on agriculture : but attending at the ſame time to arms, commerce, and the ſciences. The ſun above the cloud repreſents, not only our political ſtate in 1780, when the Academy was firſt incorporated, but alſo the riſing ſtate of *America*, in regard to empire, and the arts and ſciences.

The motto conveys the general idea, that arts and ſciences flouriſh beſt in free States.

A

L I S T

OF THE

AMERICAN ACADEMY OF ARTS AND SCIENCES.

M,DCC,LXXXV.

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A PHILOSOPHICAL DISCOURSE,

PUBLICKLY ADDRESSED TO THE

AMERICAN ACADEMY OF ARTS AND SCIENCES,

In Boſton, *on the eighth of November*, M,DCC,LXXX: *when the* PRESIDENT *was inducted into Office*.

BY JAMES BOWDOIN, ESQUIRE,

PRESIDENT *of the* ACADEMY.

GENTLEMEN *of the* AMERICAN ACADEMY *of* ARTS *and* SCIENCES!

WHEN I conſider, that among the members of the Academy there are gentlemen of abilities ſuperior to my own, eſpecially in the walks of philoſophy, I feel a conſciouſneſs, that its honours might in one inſtance have been better placed. But if a defect of abilities could be compenſated by a good will to ſerve its intereſt, and promote the end of its inſtitution, I ſhould have the ſatisfaction to think myſelf not wholly unqualified for the ſtation, with which your ſuffrages have honoured me.

It is in diſcharge of the duties of it, that I appear in this place: and in the diſcharge of them, both at preſent and on future occaſions, as I greatly need it, ſo I doubt not I ſhall always experience your candour:—the candour, which ever accompanies generous minds, and is the reſult of the due exerciſe of the ſocial affections.

The ſocial affections in man are the principal ſource of his

E happineſs;

N.B. At the deſire of the Academy, expreſſed by their vote of the 8th of November, 1780, this Diſcourſe was ſoon after publiſhed.

happineſs ; and the operation of them, as directed by his wants, and other circumſtances, forms his connections in ſociety. Their firſt objects, in the order of nature, are our relations and near friends ; next to theſe our neighbours and countrymen ſucceed ; then the people of other countries, in political connection with us ; and in the laſt place, mankind in general. In proportion, however, as theſe objects are more remote, thoſe affections are the leſs powerful. After operating on their firſt objects in our family connections, and carrying us to the vicinity, they are drawn forth more particularly to ſuch individuals as diſcover a likeneſs to ourſelves in genius and diſpoſition ; and appear to have intereſts co-incident with our own. The acquaintance thus begun, ſtrengthens and improves by time ; and the pleaſure and mutual benefits, reſulting from it, prompt us to continue and enlarge it. Theſe ſocial circles increaſe with population, and at length occaſion the eſtabliſhment of ſocieties, more effectually to ſecure thoſe benefits, and render them permanent. But the ſocial principle is of a nature ſo active and comprehenſive, that it leads mankind to aſſociate in larger bodies ; and to eſtabliſh great communities, in which the ſtrength and abilities of individuals being united and conſolidated, each individual perſonally, as well as the community at large, may enjoy the ſecurity, and advantages reſulting from that union.

Hence have originated government, and the various political connections, ſubſervient and neceſſary to it. Hence, amidſt a variety of others of different kinds, have ſprung the numerous inſtitutions for promoting philoſophical knowledge, and inveſtigating the works of nature : among which, ſome in *Europe*, and in particular, the Royal Academy of Sciences at *Paris*, and the Royal Society of *London*, bear a diſtinguiſhed character.

Hence

Hence too, the ſocieties of a ſimilar nature, which begin to adorn *America*; particularly the Philoſophical Society at *Philadelphia*, whoſe firſt eſſays, ſo ingeniouſly executed, are received by us as a pledge for ſtill nobler productions. It is hoped they will excite in this new-formed ſociety, a generous ardour and emulation in the ſame laudable purſuits; and that, as optic glaſſes, by collecting the ſolar rays, do aſſiſt and ſtrengthen the corporeal ſight, ſo the two ſocieties, by concentering in a proper focus the ſcattered rays of ſcience, may aid and invigorate the intellectual: benefiting by their productions, not only the communities in which they are reſpectively inſtituted, but *America* and the world in general: both together reſembling ſome copious river, whoſe branches, after refreſhing the neighbouring region, unite their waters for the fertilizing a more extenſive country.

The end and deſign of inſtituting this ſociety are fully declared in the act of the legiſlature for its incorporation: namely, "to promote and encourage the knowledge of the antiquities of *America*, and of the natural hiſtory of the country; and to determine the uſes, to which its various natural productions may be applied: to promote and encourage medical diſcoveries; mathematical diſquiſitions; philoſophical enquiries and experiments; aſtronomical, meteorological, and geographical obſervations; improvements in agriculture, arts, manufactures and commerce; and, in fine, to cultivate every art and ſcience, which may tend to advance the intereſt, honour, dignity and happineſs of a free, independent, and virtuous people."

Here is opened a wide and extenſive field, which the ſons of literature are invited to cultivate and improve: a field of the richeſt ſoil, ſo varied in its qualities, as to be adapted to every

mode

mode of cultivation. Here they will find abundant matter for the employment of their induſtry; and the moſt ample room for the exerciſe of their genius, in its utmoſt power of expanſion.

Here they are directed to the fountain-heads of ſcience, at which they are invited to recreate themſelves; and of whoſe delicious waters they may drink without the danger of intoxication: or in caſe of danger, contrary to the effect of ſome other waters, it diminiſhes in proportion to the largeneſs of the draught: as intimated in the elegant lines of a well-known poet.

"A little learning is a dangerous thing:
Drink deep, or taſte not the pierian ſpring.
There ſhallow draughts intoxicate the brain;
And drinking largely ſobers us again."*

We ſhall now take a curſory view of ſome of the ſubjects, which are to employ the enquiries and reſearches of this ſociety; and which we ſhall notice in the order obſerved in the act for incorporating it: making, in our progreſs, a few obſervations, that naturally reſult from them.

The antiquities of *America*, † are the firſt mentioned.—A knowledge in the antiquities of a country neceſſarily implies a knowledge of its antient hiſtory; and the reſearches into them lead directly to the ſource and original of things.

It

* *Pope's* eſſay on criticiſm.

† *Salve, magna parens frugum, Veſputia tellus,*
Magna virum: tibi res antiquæ laudis et artis
Ingrediar, ſanctos auſus recludere fontes.

VIRG: GEORG: 2.

The *American Academy* is here perſonated; and the *res antiquæ laudis, &c.*—are to be conſidered as ſubjects of their future enquiry.

The compliment paid to our country by ſubſtituting *Veſputia* for *Saturnia*, it is hoped, will be as juſtly applicable to it as *Virgil's* was to *Italy*.

It is very pleaſing and inſtructive—to recur back to the early ages of mankind, and trace the progreſſive ſtate of nations and empires, from infancy to maturity, to old age, and diſſolution:—to obſerve their origin, their growth and improvements, their different governments and laws, their variant cuſtoms and religion:—to obſerve the progreſs of the arts among them, which at firſt were few and rude, ſuggeſted by their wants and neceſſities, but gradually increaſing in number and perfection, in proportion to the enlargement of the community, and as the culture of them was encouraged:—to obſerve the riſe and gradual advancement of civilization, of ſcience, of wealth, elegance, and politeneſs, until they had obtained the ſummit of their greatneſs:—to obſerve at this period the principle of mortality, produced by affluence and luxury, beginning to operate in them: manifeſting itſelf with greater or leſs vigour in a variety of ways; and finally terminating in their diſſolution, brought upon them by the vices attendant on luxury. Debilitated by theſe, and incapable of defending themſelves againſt a vigorous invaſion, their more hardy neighbours, invited by that circumſtance, and perhaps irritated by the inſolence, which national affluence and luxury inſpire, invaded and ſubjugated them. In fine—to obſerve, after this cataſtrophe, a new face of things; new kingdoms and empires riſing upon the ruins of the old; all of them to undergo like changes, and to ſuffer a ſimilar diſſolution.

Of theſe events ancient hiſtory exhibits the moſt convincing and inſtructive evidence: particularly the hiſtory of the four great empires, the *Aſſyrian*, the *Perſian*, the *Macedonian*, and the *Roman*: which, like their founders, have long ago, ſuffered the fate incident to every thing human.

The

The knowledge of theſe events is ſo intimately connected with the knowledge of antiquities, that it is derived from the ſame ſource. Such too is the connection between ancient hiſtory and antiquities, and ſuch the mutual aſſiſtance afforded to each other, that as, on the one hand, ancient hiſtory illuſtrates and explains antiquities, ſo, on the other, antiquities ſerve to verify and authenticate ancient hiſtory, or to correct its errors: and they ſometimes give us a knowledge, or intimation of things, not recorded in hiſtory. Antiquities are alſo incidentally beneficial, by means of the political and other uſeful knowledge, reſulting from the diſquiſitions neceſſary to explain them.

With reſpect to *America*,—there may be many things of *European* extraction, that come under the name and deſcription of antiquities. So far as relate to general laws, cuſtoms and religion, they are, for the moſt part, homogeneous with what took place in the ſame age, and in the countries, from which the firſt *European* coloniſts emigrated; and it is probable they may be learnt, or explained, by the general or antiquarian hiſtory of thoſe countries. Theſe things, together with what was peculiar to thoſe emigrants, and worthy of notice, if not already recorded in *American* hiſtory, will, with other remains of antient times, be proper ſubjects of our enquiry.

Whatever relates to the aboriginal natives of *America*, not already noticed in hiſtory, may be comprized in a very narrow compaſs. Their want of civilization, and improvement, and in particular their total want of literature, by which the ſmall degree of knowledge they acquired by experience, might have been tranſmitted to ſucceeding generations, will juſtify the the opinion, that the preſent race of them, in manners and conduct, differ very little from their anceſtors, who lived centuries ago: excepting in ſome few particulars, occaſioned by

their

their intercourse with foreigners. It may naturally be conjectured therefore, that the ancient and modern history of these people, with the exception of what might regard their wars, would appear but little more than a transcript of each other; and that it would be in vain to search among them for antiquities.

It is not improbable however, there may be many ancient historical records, and other valuable remains of antiquity, both *American* and *European*, in the possession of descendants from families, which first settled *America*; and of other persons upon this continent. It were to be wished, that gentlemen possessed, or knowing, of such remains, or of any kind of collections likely to contain such, would cause them to be examined; and if they tend to elucidate, enlarge, or correct history; or in any other way can be beneficial to the public, that they would have the goodness to communicate to this society some account of them: which, at the same time it will characterize them benefactors to the public, will entitle them to the thanks of the society.

The subject next mentioned in the act is natural history.— The society are to encourage the knowledge of the natural history of the country, and to determine the uses, to which its various natural productions may be applied.

Natural history is a copious subject, or rather it includes a very great variety of subjects. The several classes of animals, vegetables, minerals and fossils—in short, every thing produced by nature, whether in the earth, the sea, or air, inclusive of these, are within its department.

The knowledge of it is so necessary to the good of mankind, that it has been cultivated in its several branches, perhaps more than any other part of science; and in proportion to that cultivation,

vation, the properties and qualities of things, and their fitneſs for certain uſes, have been diſcovered. This diſcovery has occaſioned the application of them to thoſe uſes; and thoſe have led to others, according as the wants, or the inventive faculties of man have directed. Hence we have derived the conveniences and ornaments of life, and every improvement in the arts of living.

At firſt however, at the origination of man, when it was indiſpenſibly neceſſary he ſhould be ſupplied with the means of ſubſiſtence, before he had acquired ſufficient knowledge and ability to provide for himſelf, his beneficent CREATOR, the firſt and the ſupremely great Naturaliſt, made known to him the nature and qualities of things, and the uſes to which they might be applied, ſo far as man's well-being required; and having provided for that, and endowed him with ſufficient faculties, he was pleaſed to leave him and his poſterity, to the exerciſe of thoſe faculties, for the gaining a further degree in natural knowledge: in proportion to which, and to their improving it to the purpoſes, for which it was adapted, he intended their future accommodations ſhould be. Accordingly, in different nations, from a greater or leſs exertion of equal faculties, or from a happier application of them, we find a greater or leſs degree of natural knowledge and improvements, and a proportionable difference in their reſpective conveniences and accommodations. Hence, with regard to theſe latter, the difference between *Europe* and *Africa*; between the moſt improved, and beſt accommodated, of mankind, and the Hottentots. But if their natural faculties are unequal, collectively taken, as probably is the caſe, the reaſon of that difference will ſtrike us the more forcibly.

On

On the ſuppoſition of ſuch inequality, it may in a great meaſure be accounted for, by the operation of natural cauſes : for altho' before the diſperſion of mankind over the earth, which their increaſed numbers made neceſſary, the human faculties, by reaſon of a ſameneſs in ſituation and other circumſtances, might in general be equal, yet in proceſs of time an inequality would probably take place from a change of climate.

Different climates differ greatly in their degrees of heat and cold, as well as in their natural productions. The tendency of immoderate heat is to relax, unbrace, and debilitate the human frame, and thereby diminiſh the powers of the mind as well as body, and indiſpoſe them to exerciſe and application : which indiſpoſition, ſtrengthened by the force of habit, at length becomes inſurmountable.—On the other hand, immoderate cold too much contracts, and gives too great a degree of rigidity to, the fibres, and nervous ſyſtem ; and thereby making them leſs ſuſceptible of quick and lively ſenſations, muſt proportionably affect the mind. Hence, in both caſes, an inferiority of intellects. But in climates, duely tempered with heat and cold, where the organs of ſenſe and motion are in due tone, it may be expected, if this theory be true, that mankind will be capable of greater exertions both of mind and body.*

* The Baron de *Monteſquieu*, in his *Spirit of Laws*,† where he treats, Of the difference of men in different climates, although he conſiders the effect of climate, more as it relates to the paſſions, than to the underſtanding, ſuppoſes not only that the difference is owing to different degrees of heat and cold ; but that in proportion to them the body and mind are leſs or more vigorous.

If this be the caſe, what is ſaid above reſpecting the effect of climates is not wholly juſt : for *there* it is ſuppoſed, that immoderate cold, as well as heat, diminiſhes the vigour of both.

The latter ſuppoſition may, in ſome meaſure, be ſupported by the hiſtory of the people living in the northern parts of *Norway*, *Sweden*, *Ruſſia*, *Lapland*, and *Siberia*, whoſe characters, both as to mind and body, do not give us any exalted idea of the vigour or ability of either.

† Book xiv. chap. 2. *Nugent's* tranſlation, the 2d. edit.

It will not from hence follow, that the exertions of different nations, dwelling in the ſame latitudes and climates, ſhould be equal: for on the ſuppoſition of equality of capacity, there may be a variety of things, on which their exerting it may depend: ſuch as education, religion, government, and other circumſtances, or the appearance of ſome happy genius to inſtruct and direct them: and as theſe ſhould happen to differ and influence them, their exertions would be proportionably different.

By way of illuſtration, * we may inſtance in what has taken place among ourſelves; and aſk, whether the people of theſe United States, whoſe natural capacity, without doubt, equals that of *Europeans* in the ſame temperate climates, would in certain different circumſtances, have oppoſed the unreaſonable claims of *Britain* upon them? Would they, if at all, have exerted themſelves ſo vigorouſly againſt her inſlaving domination, if they had not been educated in the principles of liberty; if their religion, like that of ſome ſects among them, had not allowed them to make uſe of carnal weapons in the defence of their liberty; or if they had lived under a deſpotic government, and believed in the doctrine of paſſive obedience and non-reſiſtance? Or, laſtly, if ſome among them, well ſituated to obſerve the courſe and tendency of *Britiſh* policy, had not alarmed them of their danger?

If all or any of theſe circumſtances had been different from, or contrary to, what have in fact taken place, the advantages derived from climate, in reference to natural capacity, had probably

* At the time of writing this diſcourſe, the fleets and armies of *Britain* were, and long had been, invading us. This circumſtance, together with the extraordinary manner, in which ſhe conducted the war, occaſioned in one or two of the political obſervations, adduced to illuſtrate the ſubject, ſome little poignancy of expreſſion: which, it is apprehended, the occaſion juſtified.

bly been loſt ; and the world had not been aſtoniſhed at the noble and unexpected exertions, we ſo happily made againſt the power of *Britain* : a power, diſtinguiſhed for its magnitude, and with which we had to contend under the preſſure of the greateſt difficulties and diſcouragements.

One ardent wiſh will be indulged to me on this occaſion, that we may ever deſerve to be poſſeſſed of freedom and independence ; and by deſerving them, convince our enemies, that the SUPREME ARBITER of the fate of nations will not ſuffer *Britain* to wreſt them from us. The firſt of them—freedom—in a conſtitutional ſenſe, while we remained connected with *Britain*, and until ſhe ſpurned our repeated prayers to her for its reſtoration, was the only object of our exertions : and the latter—independence—wholly alien at that time from our inclinations, but now radicated in them, was the neceſſary effect of her obſtinate injuſtice.

With reſpect to the Indian tribes of *America*, and the Blacks of *Africa*, if they deſcended from the ſame original ſtock, and are alike affected with the reſt of mankind, they will partake of the advantages and diſadvantages of climate in common with them : unleſs it be ſuppoſed, that the unexplored cauſe of the difference of colour may, in any meaſure, alter the effects of climate. If it doth not alter them, and if all nations in the ſame latitudes, conſidered in the groſs, have equal capacities, the difference, that on compariſon appears between them, muſt be caſual ; ariſing from ſome certain adventitious circumſtances, which take place in ſome of them, and not in others ; and which, as they ariſe, call thoſe capacities into action, and thereby occaſion that difference.

If

If by public encouragement, or by any other means, knowledge in general, and particularly natural knowledge, be ſuppoſed equal in any two or more nations, their different modes of applying it will produce very different effects ; which, taken together in each, may be equally valuable and uſeful : and if thoſe effects come under the names of manufactures, they may be exchanged for each other to mutual benefit, even where the natural materials are the ſame in kind and quality : but where the materials differ in theſe reſpects, the greater muſt be the difference in thoſe artificial productions, and the greater the benefit ariſing from the exchange.

The various productions, natural and artificial, of different countries, and the benefit reſulting from a mutual exchange of them, give riſe to commerce, navigation, and their attendants : in regard of which, the balance of advantage will always be in favour of that people, whoſe ſkill, induſtry, and cheapneſs of labour, enable them to manufacture and export, the greateſt quantity of commodities : whether manufactured from the rough products of their own, or of other countries. And that balance, if the government of ſuch a people be wiſely adminiſtred, will give them a national ſuperiority in riches, influence, and proſperity : which are principal objects with the honeſt and well-informed politician.

With reſpect to the natural productions of this country, they are perhaps as numerous as thoſe of any other : but it doth not appear by any publications on the ſubject, that they have been examined to any great extent : ſo that our natural hiſtory is very imperfect, not only in relation to ſuch productions as we have in common with other countries, but ſuch as are peculiar to our own.

own. It is apprehended, however, that gentlemen of ingenuity and obſervation, have noticed and deſcribed many of them : and that their ſeveral deſcriptions and collections, brought into one ſtock, properly methodized and claſſed, would make a reſpectable figure ; and encourage further examinations and reſearches, in order to our obtaining an extenſive, and well-digeſted body of *American* natural hiſtory. For a purpoſe ſo beneficial in itſelf, and ſo honorary to our country, it is hoped, ſuch gentlemen will favour the Academy with their deſcriptions and collections ; and alſo with the reſult of their future reſearches, relative to the ſame ſubject.

Theſe general obſervations, and particularly thoſe concerning man, and the effects of climate, with the exception of ſome few of them incidentally made, come under the head, and are included in the idea, of natural hiſtory.

What has been ſaid of the influence of climate, agrees in part with the doctrine of the celebrated *Monteſquieu.** So far as it differs from him, it may need apology : but it is ſubmitted to your candour, juſt as it ſtood written before I had conſulted him on that ſubject.

To theſe curſory obſervations on the ſubject of antiquities and natural hiſtory, I muſt here put an end, as I ſhall ſtand in need of the remains of your patience and candour, while I make a few obſervations of a different kind : which, though not neceſſarily connected with the ſubjects, that fall under the conſideration of the Academy, will not be deemed impertinent, or unſuitable to this occaſion.

The inſtituting of this ſociety, and the neceſſity there was, that it ſhould be preceded by ſuch an inſtitution as *Harvard's*, naturally

* See a foregoing marginal note.

naturally carry us back to the early times of this country, when *Harvard-College* was firſt founded.§

Our worthy anceſtors, knowing from their own experience the advantages of a good education, very early, after their coming hither, provided the means of it for their children, and poſterity; and that excellent man, Mr. *Harvard*, made a large and generous bequeſt for that purpoſe: in conſequence of which, the college was founded; and in honour of him, and to perpetuate the remembrance of his generoſity, his name was given to it. From that time to the preſent, it has been productive of the happieſt effects; and the influence and benefit of its inſtruction have been widely felt. Learning and the principles of good morals have been diſſeminated; the arts and ſciences cultivated; and a ſpirit of freedom and enquiry promoted, and encouraged: in virtue of which, the beſt foundations have been laid for excellency in the learned profeſſions.

All theſe have operated in ſo forcible and extenſive a manner, that they have produced the other ſeminaries in *America*, eſtabliſhed for the like noble purpoſes: ſo that our ALMA MATER may be juſtly conſidered as the remote parent of them all. I ſay, *our* ALMA MATER, not merely in relation to the members of this ſociety, individually conſidered, moſt of whom, from her breaſts, drew the nectareous milk of ſcience, but in relation alſo to the complex body, the ſociety itſelf: for, by her diſcipline, and unremitted inculcations, the way has been prepared for philoſophical diſquiſitions, and an examen into the works of nature: without which, or ſome ſuch preparatory diſcipline, this ſociety could not have been formed: or being formed, could not have anſwered the end of its inſtitution.

At

§ *Harvard-College* was founded in the year 1638; and the date of its firſt Charter was in 1642.

At the ſame time we are acknowledging our obligations to our ALMA MATER, juſtice demands the tribute of gratitude to her benefactors.

Foremoſt among theſe, ſtands the reverend *Harvard*; reverend by his profeſſion, but much more ſo by real worth, and true dignity of character. By his generous bequeſt, and the ſpirit it inſpired, the government was enabled to eſtabliſh the college: which, by reaſon of the low ſtate of the finances of the country, could not have been eſtabliſhed without ſuch aſſiſtance: ſo that he may juſtly be conſidered as the father and founder of the UNIVERSITY; and in that character his memory ſhould be tranſmitted to poſterity.

In the ſame catalogue alſo, the names of *Stoughton*, *Hollis*, *Holden*, *Hancock*, *Boylſton* and *Hearſey*, whoſe vital part is diſencumbered of its earthborn cottage, hold a diſtinguiſhed place. Their noble and public-ſpirited benefactions, with thoſe of other friends and encouragers of ſcience, are at large recorded in the archives of the univerſity; and therefore need not here be ſpecifically enumerated.

Ye diſembodied ſpirits, now "joined to the great majority," if ye are conſcious of what is tranſacting in this place, and will deign to regard it, permit us to expreſs our gratitude to you, ariſing from a ſenſe of the benefits already derived, and which are deriving, to individuals and the public, from your inſtitutions and benefactions.

If divinity and morality—if the knowledge of the Hebrew ſcriptures, and of the oriental and other languages—if mathematics, and natural, and experimental philoſophy—if the medical art, the belles lettres, and literature in general—are beneficial to mankind, ye have not lived in vain: ſince, to promote the know-

ledge

ledge of theſe has been the object of your aim in thoſe inſtitutions; and your aim has been crowned with the moſt happy and extenſive ſucceſs. This has inſured to you, at leaſt in this country, univerſal approbation; and your names will be remembered with honour, ſo long as literature ſhall be eſteemed, or any veſtige of it remain here.

Though wrapt in the ſhroud of death be your mortal part, ye ſtill live, and through ſucceſſive generations may ye continue to live, in the grateful breaſts of your lettered ſons.—Conſecrated to fame, and born on its ſtrongeſt pinions, may your memory reach to the remoteſt ages, expanding as it flies. And when ages ceaſe to roll—when all things ſhall be ingulphed in vaſt eternity—when eternity itſelf ſhall be abſorpt in the ſelf-exiſtence of the DEITY, may ye be bleſſed, as we humbly truſt ye now are, ſupremely bleſſed, with the approbation of HIM, who gave you the means, and the will to do good. In fine, may your virtues, and excellent example, by inſpiring imitation, procure ſuch benefactions to *Harvard-College*, as to make it, in the moſt proper and extenſive ſenſe, an *Univerſity*.

With reſpect to its ſurviving benefactors, I ſhall not attempt to name or characterize them, as the doing it might offend their delicacy, or ſavour of adulation: they will however have the pleaſing ſatisfaction to reflect, that the eulogium on the ſimilar virtues of others, is an eulogium on their own: and a conſciouſneſs of merit will compel them, without hazarding the charge of a vain-glorious appropriation, to apply it to themſelves.

To have ſaid thus much on the ſubject of the college, will not, on this occaſion, be deemed impertinent, as the inſtituting of it was, not meerly conſiſtent with the forming ſuch a ſociety as ours, but neceſſary to precede it; and as the old inſtitution

may

may with propriety be reputed the genuine parent of the new one. Such is the connection between them, and ſuch the dependence of this upon the other, that as moſt of its preſent members are ſons of HARVARD, ſo its future vernacular members will probably, for the moſt part, be ſupplied from the ſame ſtock : at leaſt ſo long as HARVARD's ſons ſhall continue to be diſtinguiſhed for ſcientific accompliſhments: which, it is fervently hoped, will be as long as ſcience, or any trait of it, remains in the world : or as long as nature, the great ſubject of it, endures.

Derived from ſuch a parentage, and animated by the noble example of other philoſophical inſtitutions, may this ſociety contribute its full ſhare to the common ſtock of knowledge ; and endeavour, by the moſt generous exertions, to anſwer the valuable purpoſes of its inſtitution.

" Rapt into future times," and anticipating the hiſtory of our country, methinks I read in the admired pages of ſome *American Livy*, or *Thucydides*, to the following effect.

A century is now elapſed ſince the commencement of *American* independency. What led to it, and the remarkable events of the war, which preceded and followed it, have been already related in the courſe of this hiſtory.

It was not to be expected, that our anceſtors, involved as they were in a civil war, could give any attention to literature and the ſciences : but ſuperior to their diſtreſſes, and animated by the generous principles, which liberty and independency inſpire, they inſtituted the excellent ſociety, called *The American Academy of Arts and Sciences*.

This ſociety formed itſelf on the plan of the philoſophical ſocieties in *Europe*, adopting ſuch rules, and principles of con-

duct, as were best suited to answer the end of its institution. Among others, they laid it down as a fundamental principle, that as true physics must be founded on experiments, so all their enquiries should, as far as possible, be carried on, and directed by them. This method was strongly recommended by Sir *Francis Bacon*, "a genius born to embrace the whole compass of science, and justly stiled, the first great reformer of philosophy,"* It was adopted by succeeding philosophers, and particularly by the immortal *Newton*, whose system of philosophy, founded on the laws of nature, will for that reason be as durable as nature itself.

Taking these great characters for their guide, and influenced by their illustrious example, they proceeded on fact and observation, and did not admit of any reasonings or deductions, but such as clearly resulted from them. This has been the uniform practice of the society: whose members, from time to time, having been chosen from men of every country, from every class and profession, without any other distinction than was dictated by the dignity of their characters, by their morality, good sense, and professional abilities, we find in the printed transactions of the society, the best compositions on every subject, within the line of their department. We find in those transactions new facts, new observations and discoveries; or old ones placed in a new light, and new deductions made from them.

They have particularly attended to such subjects as respected the growth, population, and improvement of their country: in which they have so happily succeeded, that we now see agriculture, manufactures, navigation and commerce, in a high degree of

* *Mallet's* life of Lord Chancellor *Bacon*.

of cultivation ; and all of them making ſwift advances in improvement, as population increaſes. In ſhort, they have, agreeably to the declared end of their inſtitution, " cultivated every art and ſcience, which might tend to advance the intereſt and honour of their country, the dignity and happineſs of a free, independent, and virtuous people."

This is demonſtrably evident from the numerous volumes the ſociety have publiſhed of their tranſactions. Theſe volumes are a noble collection of uſeful knowledge ; and conſidered together in their miſcellaneous ſtate, ſtrike the mind with a ſplendour, reſembling the galaxy in the heavens, derived from the combined light of countleſs myriads of conſtellations : and like that too, when the ſeveral correſponding parts are viewed in their proper connections, they appear to be parts of a whole ; and to conſtitute the moſt uſeful ſyſtems : ſyſtems diſtinguiſhed by their beauty, regularity, and proportion.——Thus far our hiſtorian.

May this prophetic hiſtory be realized by fact, and may the tranſactions of this ſociety juſtify the future hiſtorian, in giving it a character, like the one juſt delineated : or rather, a character deſervedly more exalted.

In the mean time, as the ſociety is formed on the moſt liberal principles, and is of no ſect or party in philoſophy, it wide extends its arms to embrace the ſons of ſcience of every denomination, and whereſoever found ; and with the warmth of fraternal affection invites them to a philoſophical correſpondence : and they may be aſſured, their communications will be eſteemed a favour, and duely acknowledged by the ſociety.

I ſhall cloſe this diſcourſe with a ſhort reflection, reſulting from one of the ſubjects we have been conſidering.

When

When we contemplate the works of nature, animate and inanimate, connected with our earth; obſerve the immenſe number and variety of them; their exquiſite beauty and contrivance; and the uſes to which they are adapted:—when we raiſe our view to the heavens, and behold the beauteous and aſtoniſhing ſcenes they preſent to us—unnumbered worlds revolving in the immeaſurable expanſe; *ſyſtems* beyond ſyſtems compoſing one boundleſs univerſe: and all of them, if we may argue from analogy, peopled with an endleſs variety of inhabitants:—When we contemplate theſe works of nature, which no human eloquence can adequately deſcribe, they force upon us the idea of a SUPREME MIND, the conſummately perfect author of them,—

"*That* univerſal ſpirit, which informs,
"Pervades, and actuates the wond'rous whole."

In compare with whom his works, great and ſtupendous as they are, are "nothing, leſs than nothing, and vanity." But—though annihilated by the compariſon, yet—viewed in themſelves, they powerfully perſuade us to exclaim, in the rapturous and ſublime language of inſpiration, "Great and marvellous are thy works, LORD GOD almighty, in wiſdom haſt thou made them all."

PHILOSOPHICAL MEMOIRS.

PART I.

ASTRONOMICAL AND MATHEMATICAL PAPERS.

I. *A Method of finding the Altitude and Longitude of the nonagesimal Degree of the Ecliptic; with an Appendix, containing Calculations from corresponding Astronomical Observations, for determining the Difference of Meridians between Harvard-Hall, in the University of* Cambridge, *in the Commonwealth of* Massachusetts, *and the Royal Observatories at* Greenwich *and* Paris. *In a Letter from the Reverend* JOSEPH WILLARD, *President of the University, and Corresponding Secretary of the American Academy of Arts and Sciences, to the Honorable* JAMES BOWDOIN, *L. L. D. President of the Academy.*

SIR,

AS the parallaxes of the planets in latitude and longitude come frequently into use, in astronomical calculations, and particularly in deducing the difference of meridians between one place and another, from corresponding observations

of

of ſolar eclipſes and occultations of fixed ſtars by the moon, every method which can be diſcovered, to ſhorten the work, or make it more eaſy, muſt be of utility. In calculating theſe parallaxes, it is neceſſary to find the altitude and longitude of the nonageſimal degree of the ecliptic. As I have given ſome attention to this ſubject, I take the liberty, Sir, of encloſing to you a paper, containing a method of finding theſe prerequiſites, different from any that I have happened to meet with, and (to me indeed) taking the whole proceſs together, eaſier, if not ſhorter. It is deduced from a projection which muſt make the method very obvious, to thoſe acquainted with the ſphere and with ſpheric trigonometry. You will find an appendix upon the longitude of Cambridge. If you think proper to communicate the whole to the Academy, you have my conſent.

I am,

with the greateſt reſpect, &c.

Cambridge, Auguſt 4, 1783.

DEFINITIONS.

1. THE right aſcenſion of the mid-heaven is that point of the equator, which culminates, or is in the meridian of any particular place, at a given time, and is found by adding the given apparent time, reckoned aſtronomically, to the ſun's right aſcenſion, calculated for the ſame time. Or, it may be found, by reducing the given apparent time to mean time, and adding it to the ſun's mean longitude. But, if the hours are reckoned according to civil time, we muſt take the difference between the

the apparent given time and noon; and if it is the forenoon, this difference must be substracted from the sun's right ascension; but if it is the afternoon, it must be added. If the mean longitude is taken, the mean time must be used.

2. The nonagesimal degree of the ecliptic is its highest point above the horizon, and is 90° distant from each point of the ecliptic, where intersected by the horizon. This nonagisimal point is determined by a perpendicular to the ecliptic, which passes through its poles and the poles of the horizon, the altitude of which point is measured from the horizon, upon this perpendicular.

PROBLEM.

Given the latitude of a place, the obliquity of the ecliptic, the time of the day, the sun's true longitude, his right ascension, and consequently the right ascension of the mid-heaven, to find the longitude and altitude of the nonagesimal degree of the ecliptic.

A GENERAL SOLUTION OF THE FOREGOING PROBLEM.

In plate I. fig. I. let the circle ♋p♑L represent the solstitial colures; then, the poles of the equator and of the ecliptic will be in the plane of this circle. Let the diameter E♎Q represent a portion of the equator; ♋♎♑ a portion of the ecliptic; P, the north pole of the equator; p, the north pole of the ecliptic; S and L their south poles. Let the arc Pc S mark the right ascension of the mid-heaven, from the nearest equinoctial point; then this arc will represent the meridian of some place, at a given time, and c and w will be the culminating

ing points of the equator and ecliptic. Let the arc *bZi* represent the latitude of some given place; then the point Z, where the arc is intersected by the meridian, is the zenith of the place, at the given time, and is one of the poles of the horizon; the arc HOR is the horizon; the line ZN its axis, and the point N of the axis, where it is intersected by the arc Pc S continued, is the other pole of the horizon, or the nadir. The arc *p*ZL, drawn through the poles of the ecliptic and of the horizon, marks out the longitude of the nonagesimal degree upon the ecliptic at U, the altitude of which, or height above the horizon is VU. Now the arc *p*ZL is perpendicular both to the horizon and the ecliptic, as it passes through the poles of each, and as *p*U is = ZV = 90° and ZU is common to both, take ZU from each, and there will remain *p*Z = VU the altitude of the nonagesimal degree of the ecliptic. The longitude and altitude of this point, therefore, may be readily found by the spheric triangle P*p*Z, in which are given two sides and the included angle, viz. side PZ = the co-latitude of the given place; the side P*p* = the distance of the poles of the equator and ecliptic = the obliquity of the ecliptic; and the angle *p*PZ, the value of which may always be determined by the following general rules, which, from diagrams, will appear very obvious.

The right ascension of the mid-heaven being between 270° and 360° or 0°, and between 0° and 90°, the nearest equinoctial point is ♈; and in the first case, angle *p*PZ is acute, and is found by substracting 270° from the right ascension of the mid-heaven. In the second case, the angle is obtuse, and is found by substracting 270° from the right ascension of the mid-

mid-heaven added to 360°, or, which is the ſame thing, by adding the right-aſcenſion of the mid-heaven to 90°.

The right aſcenſion of the mid-heaven being between 90° and 180°, and between 180° and 270°, the neareſt equinoctial point is ♎ ; and in the firſt caſe, angle pPZ is obtuſe, in the ſecond acute, and in each caſe the angle is found, by ſubſtracting the right-aſcenſion of the mid-heaven from 270°. Theſe rules are to be uſed when the latitude of the given place is north ; but when it is ſouth, they muſt be inverted to find the correſponding angles, as will appear evident by a diagram.

From Z, let fall the perpendicular Zx upon the primitive circle : And to know whether the perpendicular, in any caſe, will fall upon the ſide of P next to p, or oppoſite to it, the following rules may be obſerved.

When the right aſcenſion of the mid-heaven is between 180° and 270°, or between 270° and 0°, that is, when angle pPZ is acute, the perpendicular will fall upon the ſide of P next to p ; but when the right aſcenſion of the mid-heaven is between 0° and 90°, or between 90° and 180°, that is, when angle pPZ is obtuſe, the perpendicular will fall upon the ſide of P oppoſite to p.

For the ſide pZ, the altitude of the nonageſimal degree. Radius : Sine co-angle pPZ :: Tangent ſide PZ : Tangent ſide Px. Then, if the perpendicular be on the ſide of P next to p, the difference between Pp and Px will be px ; but if it fall on the ſide of P oppoſite to p, the ſum of Pp and Px will

will be *px*. *px* being found ſay, Sine co-P*x* : Sine co-*px* :: Sine co-PZ : Sine co-*p*Z.

For angle P*p*Z, or ∠ at the pole of the ecliptic, Sine ſegment *px* : Sine ſide P*x* :: Tangent angle *p*PZ : Tangent angle P*p*Z.

When the perpendicular Z*x* falls upon the ſide of P oppoſite to *p*, or between P and *p*, the angle P*p*Z is acute; but when it falls beyond *p*, it is obtuſe.

By the angle P*p*Z, the longitude of the nonageſimal degree is determined thus:—When the neareſt equinoctial point is ♈, ſubſtract this angle from ♋ or 3^s, adding 12^s to 3^s, when neceſſary; the remainder will be the longitude of the nonageſimal degree. If the neareſt equinoctial point is ♎, add this angle to ♋ or 3^s, and the ſum will be the longitude of the nonageſimal degree.

Let the foregoing general rules be now elucidated by a particular

EXAMPLE.

Required the longitude and altitude of the nonageſimal degree of the ecliptic, at the royal obſervatory at Greenwich, Auguſt 5, 1766, at $5^h\ 29'\ 57''$ P. M. apparent time?

The ſolar and lunar elements from MAYER's tables.

At $5^h\ 29'\ 57''$ P. M.	
The ſun's longitude	$4^s\ 13^\circ\ 9'\ 51''$
The obliquity of the ecliptic	23 28 18

The

The latitude of Greenwich	51° 28′ 39″
Reduced to the center, the earth being an oblate ſpheroid	51 14 11
Complement = PZ	38 45 49

For the ſun's right aſcenſion.

Radius		10
: Sine of the co-obliquity of the ecliptic,	66° 31′ 42″	9 9624911
:: Tang : ☉'s longitude from neareſt equinoct point,	46 50 9	10 0278498
: Tang : ☉'s right aſcenſion from neareſt point, viz. ♎	44 21 46	9 9903409
Subſtract the above from	180 0 0	
The remainder is ☉'s right aſc. from ♈	135 38 14	

The given time $5^h\ 29'\ 57''$ being reduced to degrees, at the rate of 15° per hour, gives 82° 29′ 15″. Add this to the ſun's right aſcenſion 135° 38′ 14″; the ſum 218° 7′ 29″ is the right aſcenſion of the mid-heaven. This ſubſtracted from 270° according to the rule, leaves 51° 52′ 31″ for angle *p*P*z*.

For ſide *p*Z, the altitude of the nonageſimal degree.

Radius			
: Sine Co ∠*p*PZ		38° 7′ 29″	9 7905493
:: Tangent	PZ	38 45 49	9 9047023
: Tangent	P*x*	26 22 10	9 6952516
Subſtract	P*p*	23 28 18	
Remains	*px*	2 53 52	

Sine Co Px	63°	37′	50″	9	9522832
: Sine Co px	87	6	8	9	9994443
:: Sine Co PZ	51	14	11	9	8919475
: Sine Co pZ	60	21	48	9	9391086
Alt. nona. deg. pZ	29	38	12		

For angle Ppz

Sine px	2°	53′	52″	8	7037573
: Sine Px	26	22	10	9	6475369
:: Tangent ∠pPZ	51	52	31	10	1052425
: Tangent ∠PpZ	84	53	49	11	0490221
Obtuse =	95	6	11		

To ♋ =	3ˢ	0°	0′	0″
Add ∠PpZ =	3	5	6	11
The sum is = the long. of nona. deg.	6	5	6	11

By the foregoing process it appears, that the longitude of the nonagesimal degree is 6ˢ 5° 6′ 11″, and the altitude 29° 38′ 12″.

APPENDIX.

APPENDIX.

THE aſcertaining of the difference of longitude between various places on the globe, particularly between important headlands and ſeaports, and alſo between places where aſtronomic obſervations are made, to perfect the knowledge of the heavens, and to improve navigation and geography, are very deſirable objects. Obſervations of eclipſes of the moon and of Jupiter's ſatellites have frequently been made uſe of for this purpoſe. When the beginning or ending has been obſerved in two places, the difference in time is the difference of meridians, which may be reduced to degrees, at the rate of 15° per hour. But the earth's ſhadow is ſo imperfectly defined at the moon, that the beginning or ending of a lunar eclipſe cannot be ſo ſatisfactorily determined, that the difference of meridians, deduced from theſe obſervations, can be entirely depended upon. The beginning or ending of the eclipſes of Jupiter's ſatellites can be determined with more preciſion; but ſtill, much depends upon the magnifying powers and the aperture of the teleſcopes, which are made uſe of for the obſervation: nor is the difference of meridians between two places, deduced from theſe obſervations, reckoned accurate, unleſs there is a conſiderable number, both of immerſions and emerſions, to be compared with correſponding ones. Of late years, therefore, obſervations of ſolar eclipſes, of occultations of fixed ſtars by the moon, and of tranſits of the inferior planets over the ſun's diſk, when made under favourable circumſtances, have been moſt ſought for, and uſed, when they could be obtained, for determining differences of meridians. In theſe obſervations, the difference of times is not the difference of meridians,

ridians, but is ſometimes more, and ſometimes leſs, according to the parallaxes. Theſe, therefore, muſt be carefully computed; and the tediousneſs of the proceſs has, doubtleſs, prevented obſervations of this kind from becoming ſo generally uſeful, as they would otherwiſe have been. But, as the difficulty may appear leſſened, by having the whole operation brought into one view, I now take the liberty of doing it, for the ſake of thoſe who have not made great advances in aſtronomy, ſhould any ſuch meet with this paper. I have taken, for examples, thoſe obſervations which have led to a determination of the difference of meridians between London and Cambridge, and Paris and Cambridge. An accurate determination of this difference may be very uſeful. Hereby, the aſtronomic tables, which have been fitted to the meridians of the celebrated obſervatories of Paris and Greenwich, are made our own, for all the purpoſes of calculation; and our obſervations may be made uſe of, for correcting and improving thoſe tables: And ſhould new ones be conſtructed for Cambridge, the ſame may be accommodated to the European obſervatories.

PROBLEM.

Given the moon's longitude, latitude, horizontal parallax and horizontal ſemi-diameter, together with the altitude of the nonageſimal degree of the ecliptic, and the angle of it's pole, or angle P*p*Z, and conſequently the longitude of the nonageſimal degree, to find her parallax in latitude and longitude, her viſible ſemi-diameter, or ſemi-diameter augmented agreeably to her altitude or zenith diſtance, and the viſible difference of longitude between the ſun and moon?

If

If the procefs be trigonometrical we muft firft find the moon's altitude and parallactic angle.

In plate I, figure I, let the arc *pe*L cut the ecliptic in *e* = the moon's longitude, and let the arc *l a t* mark out her latitude; then the point of interfection of the two arcs at ☽, will be the moon's true place or pofition. Let the vertical arc Z☽N be drawn; then, in the triangle *p*☽Z, the fide Z☽ will be the moon's zenith diftance, or co-altitude, and the angle *p*☽Z her parallactic angle; to find which, there are given two fides and the included angle, viz. the fide *p*Z = the altitude of the nonagefimal degree; the fide *p*☽ = the moon's diftance from *p* one of the poles of the ecliptic = the complement of her latitude, and the angle Z*p*☽ = the difference between the moon's longitude and the longitude, of the nonagefimal degree.

From Z let fall the perpendicular Z*d*, dividing the oblique angled triangle *p*☽Z into two right-angled triangles, right-angled at *d*.

For fide Z☽ the moon's zenith diftance.

Radius : Sine Co-angle Z*p*☽ :: Tangent *p*Z : Tangent *pd*.
Take *pd* from *p*☽ and the remainder will be ☽*d*; then fay
Sine Co-*pd* : Sine Co-☽*d* :: Sine Co-*p*Z : Sine Co-Z☽.

For angle *p*☽Z, the moon's parallactic angle.

Sine ☽*d* : Sine *pd* :: Tangent angle Z*p*☽ : Tangent angle *p*☽Z.

We muft next find the moon's parallax in altitude, preparatory to which, let the moon's diftance from the earth in femidiameters of the earth be found.

In plate I, figure II, in the plain right-angled triangle B A C, right-angled at B, let C B be the ſemi-diameter of the earth, which call 1, the angle B A C the moon's horizontal parallax, the hypotenuſe C A the moon's diſtance from the earth's center in ſemi-diameters of the earth, to find which ſay Sine angle B A C : ſide B C :: Radius : hypotenuſe C A.

Having found the moon's diſtance from the earth's center, there are given in plate I, figure III, in the plain oblique-angled triangle B A C, the ſide A C = the moon's diſtance from the earth's center, the ſide B C = the earth's ſemi-diameter, and the included angle B C A = the moon's true zenith diſance, to obtain angle B A C = the difference between angle B C A the true zenith diſtance and D B A the viſible zenith diſtance = the moon's parallax in altitude; to find which, ſubtract angle B C A from 180° the ſum of the three angles, the remainder will be the ſum of the two unknown angles A B C and B A C: Take the ſum and difference of the ſides A C and B C; then ſay, the ſum of the two ſides A C and B C : their difference :: the Tangent of half the ſum of the two unknown angles : the Tangent of half their difference. Subtract the half difference from the half ſum, and the remainder will be the leſſer angle BAC = the moon's parallax in altitude,* which added

* The common method of deducing the moon's parallax in altitude from her true zenith diſtance is by approximation; finding the parallax for the true zenith diſtance as if it were the viſible, by adding together the logarithmic Sine of the zenith diſtance and of the horizontal parallax: then adding the parallax thus found to the true zenith diſtance, and conſidering the ſum as the viſible zenith diſtance, and then going over the work again; but I have exhibited the above method as the direct one; and it is but little longer than the other.

added to the true zenith diſtance, will give the viſible = angle DBA.

For the parallax in latitude and longitude.

Having found the moon's parallax in altitude ſuppoſe it ſet off plate I, figure I, upon the vertical arc from ☽ to *m* towards the horizon, becauſe the viſible zenith diſtance is greater than the true; then, the point *m* will be the moon's viſible place, or her place as ſeen from ſome given ſpot on the earth's ſurface. From *p* to L, through *m*, let the arc *pm*L be drawn; then, in the triangle *pm*☽, the angle *mp*☽ = the diſtance between *n* and *e* on the ecliptic is the moon's parallax in longitude; and the ſegment *my*, of the ſide *pm*, is her parallax in latitude; to find which by ſpheric trigonometry, there are given two ſides and the included angle, viz. ſide *p*☽, the moon's diſtance from the pole of the ecliptic; the ſide ☽*m*, the moon's parallax in altitude, and angle *p*☽*m* = the ſupplement of angle *p*☽Z to 180°. Or it may be more convenient to take the triangle L☽*m*; in which are given ſides L☽ and ☽*m* and the included angle L☽*m*, = *p*☽Z to obtain the ſame things. But the moon's parallax in latitude and longitude may be found more eaſily, by the following method.—Let fall the perpendicular *mr* upon the arc *p*☽L; then, there will be formed a right-angled triangle ☽*mr*, right-angled at *r*. As the perpendicular *mr*, in eclipſes of the ſun, and even in occultations of fixed ſtars by the moon, will always be near the ecliptic, it may be conſidered as parallal to it, without any ſenſible error; conſequently, the ſide *mr* may be reckoned = the ſegment *ym*. We may therefore call the ſide ☽*r* the moon's parallax in latitude, and the ſide *mr*, augmented in the ratio of the Sine of the moon's viſible co-latitude to radius,

dius, will be equal to *ne*, the parallax in longitude. In occultations, when the moon's latitude is conſiderable, this augmentation muſt take place; but in ſolar eclipſes, her latitude is always ſo ſmall, that the difference between *mr* and *ne* is imperceptible; therefore, *mr* may be conſidered as the true parallax in longitude.

As the ſides of the triangle ☽*mr* are very ſhort, it may be reckoned a plain one, without any perceptible error; and the ſides ☽*r* and *mr* may be found by plain right-angled trigonometry, the hypotenuſe ☽*m*, and the angle *m*☽*r* = angle *p*☽Z, being given.

For ſide ☽*r*, the moon's parallax in latitude.

Radius : ☽*m* in ſeconds :: Sine co-angle *m*☽*r* : ſide ☽*r* in ſeconds.

For ſide *mr*, the parallax in longitude.

Radius : ☽*m* in ſeconds :: Sine angle *m*☽*r* : ſide *mr* in ſeconds.

General rules for applying the Parallaxes.

In a place in north latitude, when the moon's latitude is north, if the parallax in latitude is leſs than the true latitude of the moon, ſubtract it from her latitude; the remainder will be her viſible latitude north. If the parallax be the greater, ſubtract her latitude therefrom; the remainder will be the moon's viſible latitude ſouth. If the true latitude of the moon be ſouth, the parallax in latitude, whether greater or leſs, muſt be added, and the viſible latitude will be ſouth. Theſe rules muſt be inverted, when the latitude of a place is ſouth.

The

The parallax in longitude muſt be added to the moon's true longitude, to give the viſible, when her true longitude is to the eaſt of the nonageſimal degree, otherwiſe, it is to be ſubtracted.

If the moon's true latitude and longitude are to be found from the viſible, the above rules, for applying the parallaxes, muſt be inverted.

For the moon's augmented or viſible ſemi-diameter according to her altitude or zenith diſtance.

The viſible diameter of the moon, to a ſpectator on the ſurface of the earth, is continually enlarging, from the horizon to the zenith; becauſe the ſemi-diameter of the earth bears a ſenſible proportion to the moon's diſtance. When the moon is in the zenith of an obſerver on the earth's ſurface, ſhe is nearer to him by almoſt a whole ſemi-diameter of the earth, than when ſhe is in his horizon. In the horizon, therefore, the moon's viſible diameter muſt be the leaſt, and in the zenith the greateſt of all.

The viſible diameter of any planet is inverſely as it's diſtance from us; therefore, to find the moon's augmented ſemi-diameter, from her horizontal, at a particular zenith diſtance, we muſt ſay,—The moon's diſtance from the earth's ſurface at the given viſible zenith diſtance : her horizontal diſtance, or diſtance from the earth's center† :: her horizontal ſemi-diameter : her augmented or viſible ſemi-diameter at the given zenith diſtance. But ſides of plain triangles are meaſured by the ſines of

† The moon's diſtance from a ſpectator at the earth's center is the ſame, at every altitude, as her horizontal diſtance.

of the opposite angles; thus in plate I, figure III, sine angle BCA, the moon's true zenith distance, measures the side AB, the moon's distance from a spectator on the earth's surface; and sine angle A B C, or which is the same, sine angle DBA, the moon's visible zenith distance measures the side A C, the moon's distance from the earth's center = her horizontal distance. We may therefore say, Sine angle A C B, the moon's true zenith distance : sine angle D B A, her visible zenith distance :: her horizontal semi-diameter : her augmented or visible semi-diameter.*

For the visible difference of longitude between the center of the sun and moon.

To obtain this, there are given the sum of the sun's horizontal semi-diameter, and the moon's augmented or visible semi-diameter, at the time of the observed beginning or ending of the eclipse, for which the calculation is made, and the visible latitude of the moon from the sun, found by properly applying the parallax of latitude from the sum, by which a plain right-angled triangle may be formed. Thus in the plain right-angled triangle ☉E☽, plate I, figure IV, there will be given the hypotenuse ☉☽ = the sum of the semi-diameter of the sun or moon,† or visible distance of their center, and the side E☽, the

* The augmentation of the moon's semi-diameter to her altitude or zenith distance may be found in some astronomical tables; but I thought it best to give the trigonometrical process.

† This sum of the semi-diameter ought to be diminished, on account of difffraction, or the inflection of the rays which pass the limbs of the moon, supposed to be caused by her atmosphere. When an eclipse or occultation would appear to us to be just begun, were there no inflexion, this causes her limb to be visibly distant from

the visible difference of latitude between their centers, to find the side ⊙E, their visible difference of longitude.* This may be obtained by Euclide, Book I, Prop. 47; or it may be found by common trigonometry thus ⊙☽ : Radius :: E☽ : sine angle E⊙☽; then Radius : ⊙☽ :: sine co-angle E⊙☽ = angle E☽⊙ : ⊙E. But ⊙E may be obtained more expeditiously, thus; find the logarithms for the sum and difference of ⊙☽ and E☽; the half sum of these logarithms is the logarithm of ⊙E.

Having found, for the place from whence we design to reckon the difference of meridians, the parallaxes, and the visible difference of longitude between the centers of the sun and moon, at the observed time of the beginning or ending of a solar eclipse, or occultation of a fixed star, or for both the beginning and ending, where both have been observed, we must assume the difference of meridians in time, between the first

C place,

from the limb of the sun, or from the fixed star $4\frac{1}{2}''$: Therefore, at the instant when the beginning or end appears to us, it is obvious, that the centers cannot be so far asunder by $4\frac{1}{2}''$, as the sum of the semi-diameters; and by so much must this sum be diminished. For a brief account of this inflection, see ASTRONOMIE par M. DE LA LANDE, tome ii. art. 1992, 1993, edition seconde.

* As the sun has a visible latitude, equal to his parallax in latitude, the side ⊙E is not a portion of the ecliptic, but is parallel to it: But as it's utmost distance from it can never be more than between 8″ and 9″, the difference between this side and the visible difference of longitude, is imperceptible. In an occultation, when the star's latitude is large, this side, parallel to the ecliptic, must be enlarged, to give the visible difference of longitude between the star and the moon's center, in the ratio of the cosine of the moon's visible latitude, or of the star's latitude to Radius, according as the one or the other is nearest to the ecliptic.

place, and that whoſe longitude is ſought; and muſt find the parallaxes the augmented ſemi-diameter of the moon and the difference of longitude between the centers of the ſun and moon, or ſtar and moon, for the obſerved time of the beginning or ending of the eclipſe, or occultation, at this ſecond place.

We are next to find the time of the true ecliptic conjunction of the moon and ſun, or moon and ſtar, according to obſervation: And here we are to obſerve, that at the beginning of an eclipſe or occultation, the moon is viſibly not ſo far advanced in longitude, as the ſun or ſtar, therefore, if we ſubtract the viſible difference of longitude from the ſun's viſible longitude,* or from the ſtar's true longitude,† we ſhall have the viſible longitude of the moon. If to this viſible longitude, we apply her parallax in longitude, with it's proper ſign, we ſhall have her true longitude according to obſervation, the ſun's or ſtar's longitude being ſuppoſed to be accurately given by the tables. If we make uſe of the moon's parallax in longitude from the ſun inſtead of her ſimple parallax, which will prevent a ſeparate calculation for the ſun's parallax in longitude, the viſible difference of longitude being ſubtracted from, or added to the ſun's true longitude will give the moon's viſible longitude nearly; and her parallax in longitude from the ſun properly applied to this will give her true longitude.

The

* The ſun's viſible longitude is found by applying his parallax in longitude with the proper ſign to his true longitude.

† As the fixed ſtars have no perceptible parallax, there can be no diſtinction in calculations between the viſible and true longitude.

The difference between the ſun's or ſtar's longitude and the moon's thus found will, it is obvious, be the true difference of longitude between them. But this may be ſound more readily thus—In eclipſes, if the viſible difference of longitude and the moon's parallax in longitude from the ſun, and in occultations, the moon's ſimple parallax, be both additive or both ſubtractive, their ſum is the true difference of longitude, between the moon and ſun or ſtar. If the one is additive, and the other ſubtractive, their difference is the difference of longitude.

It ſometimes, though rarely, happens, that the moon, at the beginning of an eclipſe or occultation, has paſt the true conjunction,* although her viſible longitude is leſs; this is the caſe when the parallax, being additive, is greater than the difference of longitude between the moon and ſun or ſtar. We muſt invert this rule, to know whether the moon has paſt the true conjunction, at the end.

The true difference of longitude between the moon and ſun, or moon and ſtar being found, both for the beginning and ending of a ſolar eclipſe, or of an occultation, where both have been determined by obſervation, the ſum of theſe, when the moon was on different ſides of the point of the true ecliptic conjunction, at the beginning and ending or the difference, when ſhe was upon the ſame ſide in both, will be her whole motion in longitude from the ſun or ſtar during the time of the

 eclipſe

* We ſhall find an inſtance of this at the beginning of the ſolar eclipſe at Greenwich, June 24, 1778.

eclipſe or occultation, according to obſervation.* Then we muſt ſay, This whole motion : the whole time of the duration :: the difference of longitude at the beginning or ending : the diſtance in time between the obſerved beginning or ending and the true ecliptic conjunction.

When the beginning or ending only has been obſerved, at the places for which we made the calculations, we muſt uſe the moon's horary motion from the ſun, as given by the tables, for the firſt term, and one hour or 3600″, for the ſecond term.

The time thus found is to be added to the obſerved time of the beginning of the eclipſe or occultation, when the moon is behind the true conjunction ; but if ſhe has paſſed it, then it muſt be ſubtracted ; and the ſum or difference will be the time of the true ecliptic conjunction according to obſervation. This

* If this whole motion is conſiderably different from that given by the tables, and we make dependance upon the obſervations of the beginning and end of the eclipſe or occultation, we are to conclude, that the moon's latitude, by the tables, is not exact ; and the correct latitude muſt be ſought, for the beginning and end. Theſe being obtained, the viſible difference of longitude between the ſun's and moon's center is to be found, conformably thereto. By this it is ſuppoſed, that the moon's horary motion, by the tables, is true ; which may be concluded to be generally the caſe, in eclipſes and occultations ; and indeed it is much more likely that the latitude ſhould be given too ſmall or too large, in the tables, than that the horary motion ſhould be conſiderably erroneous by them. In more than five hundred longitudes of the moon, calculated from Mayer's printed tables, by M. Lemery, which he compared with correſponding longitudes, deduced from the lunar obſervations of the late accurate and celebrated Dr. Bradley ; which compariſons are publiſhed in *Connoiſance des Temps pour l' Annèe*, 1783, I find that the error in the moon's horary motion in longitude rarely amounts to 2″. It is not common for it to exceed 1″ ; and it is generally but a few tenths of a ſecond. We may therefore make great dependance upon the horary motion given by theſe tables.

This rule is to be inverted, to find the time of conjunction from the observation of the end of the eclipse or occultation.

The time of the true ecliptic conjunction, according to the observations, being found in this manner, for each place, the difference of times will be the difference of meridians.

Let the preceding rules be now exemplified.

The beginning of a solar eclipse was observed at the Royal Observatory at Greenwich, by Dr. Maskelyne, the Astronomer Royal, August 5, 1766, at $5^{h.} 29' 56''$ P. M. apparent time, and by his assistant at $5^{h.} 29' 58''$ P. M. the mean being $5^{h.} 29' 57''$. The end was observed by the Doctor at $7^{h.} 11' 27''$, and by his assistant at $7^{h.} 11' 40''$ P. M. the mean being $7^{h.} 11' 33''\frac{1}{2}$.

The same eclipse was observed by the late Dr. Winthorp, Hollis Professor of the Mathematics and Natural Philosophy, at Cambridge, who made the beginning at $11^{h.} 39' 23''$ A. M. and the end at $2^{h.} 45' 9''$ P. M. apparent time.

Required the difference of meridians between Greenwich and Cambridge, by these corresponding observations?

The solar and lunar elements for calculating the parallaxes, &c. are from Mayer's tables.

For Greenwich at $5^{h.} 29' 57''$.

The sun's longitude,	$4^{s.}$	13°	$9'$	$51''$	o
The moon's ecliptic longitude,	4	13	3	59	o

The

The moon's latitude north decreasing,	°	33′	17″	0
The sun's horary motion,		2	43	2
The moon's horary motion in longitude in the ecliptic,		29	29	5
The moon's horary motion in latitude,		2	43	2
The moon's horizontal parallax for Greenwich,		53	58	4
The sun's horizontal parallax,			8	4
The moon's horizontal parallax from the sun,		53	50	0
The sun's horizontal semi-diameter by observation,		15	47	0
The moon's horizontal semi-diameter,		14	44	5
The obliquity of the ecliptic,	23	28	18	0
The latitude of Greenwich Observatory,	51	28	39	
Reduced to the center,	51	14	11	
Complement = PZ	38	45	49	

From these elements the altitude of the nonagesimal degree

has already been found,	S.	29°	38′	12″
And it's longitude,	6	5	6	11
From which subtract the moon's longitude,	4	13	3	59
The difference is equal to angle Zp ☽,	1	22	2	12
		= 52	2	12

For the moon's zenith distance and parallactic angle. Plate I.

Figure I.

For side Z ☽.

Radius,						
: Sine Co-angle	Zp ☽	37	57	48	9	7889864
:: Tangent	pZ	29	38	12	9	7550557
: Tangent	pd	19	17	20	9	5440421
	p ☽	89	26	43		
	☽d	70	9	23		

Sine

Sine Co	*pd*	70	42	40	9	9749099
: Sine Co	☽*d*	19	50	37	9	5307810
:: Sine Co	*p*Z	60	21	48	9	9391086
: Sine Co	Z☽	18	12	56	9	4949797
		90				
☽'s zen. dist.	= Z☽	71	47	4		

For angle *p*☽Z.

Sine	☽*d*	70	9	23	9	9734755
: Sine	*pd*	19	17	20	9	5189498
:: Tangent angle	Z*p*☽	52	2	12	10	1077631
: Tangent angle	*p*☽Z	24	13	55	9	6532974

= *m*☾*r* the parallactic angle.

For the moon's distance from the earth in semi-diameters of the earth. Plate I. Fig. II.

Sine angle BAC = the moon's horizontal parallax from sun,	0° 53′ 50″	8	1947596
: BC, the earth's semi-diameter,	1		
:: Radius		10	
: AC, the moon's distance from the earth's center,	63 8617*	1	8052404

For

* This is not strictly the moon's distance from the earth, because her horizontal parallax from the sun is here used, instead of her true parallax; but the number thus found is to be taken for the next process, because, in these calculations, we find her parallax in altitude, latitude and longitude from the sun, to prevent separate processes for his parallaxes. When we are making these calculations in occultations of the fixed stars by the moon, her true horizontal parallax will necessarily be used, because the fixed stars have no discoverable parallax.

For the moon's parallax in altitude. Plate I, Fig. III.

Sum of the three angles,	180° 0′ 0″
Angle BCA = ☽'s zenith diſtance,	71 47 4
Sum of the two unknown ∠'s	180 12 56
Half ſum	54 6 28
Side CA = ☽'s diſtance from the earth's center,	63 8617
Side BC = earth's ſemi-diameter,	1
Sum of the two ſides including the known angle,	64 8617
Their difference,	62 8617

The ſum of the two ſides including the known angle,	64 8617	1 8119883
: Their difference,	62 8617	1 7983861
:: Tangent ½ ſum of the two unknown angles,	54° 6′ 28″.	10 1404579
: Tangent ½ their difference,	53 15 5	10 1268557
Leſſer angle BAC or ☽'s parallax in altitude from ſun,	51 23	
	60	
	.3083	

The finding of the moon's parallax in altitude, from her true zenith diſtance, may be much facilitated by the following ſhort table, which I have calculated for the purpoſe.

TABLE.

T A B L E.

☽'s horiz. par$^{x.}$	Logarithms.	Difference.
53′	0 0133919	2526
54	0 0136445	2526
55	0 0138971	2526
56	0 0141497	2527
57	0 0144024	2527
58	0 0146551	2527
59	0 0149078	2528
60	0 0151606	2528
61	0 0154134	2528
62	0 0156662	

The firſt column of this table contains the moon's horizontal parallaxes in minutes. In the ſecond column are the logarithms, which are to be ſubtracted from the logarithmic tangent of the half ſum of the two unknown angles (found as above) according to the moon's horizontal parallax. The remainder will be the logarithmic tangent of the half difference of thoſe angles. The degrees, &c. anſwering to this, being ſubtracted from the half ſum, will give the parallax in altitude.

The uſe of the table exemplified.

Required the moon's parallax in altitude from the ſun, her horizontal parallax from the ſun being 53′ 50″, and her true zenith diſtance 71° 47′ 4″, as before?

The Tang. $\frac{1}{2}$ ſum of the two unknown angles, as above,	54° 6′ 28″	10 1404579
Logarithm from the table for	53 50	0 0136024
The Tang. $\frac{1}{2}$ difference of the two unknown angles,	53 15 5	9 1268555
The moon's parallax in altitude from the ſun, as before,	51 23	

D For

For the moon's parallax in altitude from the sun by approximation.

Sine of the moon's true zenith distance,	71° 47′ 4″	9 9776721
The moon's horiz. par. from the sun,	3230*	3 5092025
Moon's par. in altitude from sun nearly	3068	3 4868746
	= 51′ 8″	
	71 47 4	
The moon's visible zen. dist. nearly	72 38 12	Sine 9 9797448
	3230″	Log. 3 5092025
The moon's par. in alt. from the sun,	3082, 8	3 4889473

This is but $\frac{2}{10}$ of a second different from the parallax which was found by the direct method.

For the moon's parallax from the sun in longitude and latitude. Plate I, Figure I.

Radius		
: ☽*m* the moon's parallax in altitude from the sun,	3083″	3 4889735
:: Sine angle *p*☽Z = *m*☽*r* the parallactic angle,	24° 13′ 55″	9 6132407
: *mr* the moon's parallax in longitude from the sun,	1265, 3	3 1022142
	= 21′ 5″, 3	
Radius		
: ☽*m*	3083″	3 4889735

:: Sine

* The arc of this parallax is so small, that we may use the logarithm of the seconds contained in it, instead of the sine of the arc without any sensible error.

:: Sine co-angle *p☽Z*	65° 46′ 5″	9 9599432
: ☽*r* the moon's paral. in lat. from sun, 2811, 3		
	= 46′ 51″, 3	3 4489167

For the moon's visible or augmented semi-diameter.

The Sine of the moon's true zen. dist.	71 47 4	9 9776721
: The Sine of her visible zen. dist.	72 38 27	9 9797546
:: Her horiz. semi-diameter, 14′ 44″, 5 = 884″, 5		2 9466978
: Her augmented semi-diameter,	888, 8	
		2 9487803

Such is the trigonometrical process, for finding the moon's parallax in latitude and longitude, and her augmented or visible semi-diameter; but astronomers have invented *formulas*, which greatly shorten the work, making it unnecessary to find the moon's zenith distance, parallactic angle, and parallax in altitude. In solar eclipses, the moon's latitude being very small, the *formulas* are quite concise and easy.

Let the parallax in latitude be called x, and in longitude y. Let the co-sine of the altitude of the nonagesimal degree be called C and it's sine D. Let the moon's horizontal parallax or her horizontal parallax from the sun be called p, her *visible* latitude l, and *true* latitude L. Let the distance between the moon's *visible* longitude and the longitude of the nonagesimal degre = Zpm in Plate I, Fig. I, be called b; the *true* = $Zp☽$, B. Then, the *visible* latitude and longitude of the moon being given,

$x = pC \mp pD$ sine l co-sine b,

$y = pD$ sine b.

The

The ſubtractive ſign — is to be uſed, when the moon's latitude is north, the additive + when it is ſouth.

In occultations, when the moon's latitude is large,
$x = p$C co-ſine $l \mp p$D ſine l co-ſine b.

$y = \dfrac{pD \text{ ſine } b}{\text{Co-ſine L}}$ } i. e. y, found by pD ſine b, muſt be enlarged in ratio of the co-ſine of the moon's true latitude to Radius.

Formulas have been invented to find the parallaxes in a direct way, when the moon's *true* latitude and longitude are given; but it is rather eaſier, in this caſe, to come at them by approximation, thus,

Add together logarithm p, ſine D, ſine B, which will give y, or the parallax in longitude nearly. Add the parallax thus found to B, which will give b nearly, viz. the diſtance between the moon's *viſible* longitude and the longitude of the nonageſimal degree. Then log. p, ſine D, ſine b thus nearly found, will give y, the parallax in longitude, ſufficiently exact; and this added to B will give correct b. Add together log. p, ſine C, which will give x, or the parallax in latitude nigh the truth. This being properly applied to L, the moon's *true* latitude, will make l, the *viſible* latitude, nearly. Then add together log. p, ſine D, ſine l, thus nearly found, and co-ſine b, which give the logarithm of a number, that added to, or ſubtracted from x, as before nearly found, will make the correct parallax in latitude.

With reſpect to the moon's augmented ſemi-diameter we may ſay B : C :: the moon's horizontal ſemi-diameter : her augmented

mented ſemi-diameter. Her augmented ſemi-diameter, thus found, will be ſufficiently correct for all purpoſes.

Exemplification.

The co-altitude of the nonageſimal degree,	60° 21′ 48″	Sine 9 9391086	C
The altitude of the nonageſimal degree,	29 38 12	Sine 9 6941647	D
The moon's horiz. par. from the ſun,	53′ 50″ = 3230″	Log. 3 5092025	*p*
The diſt. between the moon's true long. and the long. of the nonageſimal degree,	52 2 12	Sine 9 8967492	B
The moon's true latitude,	33 17 N = L		

p 3 5092025
D 9 6941970
B 9 8967492

y nearly 1259″ 3 1001487
= 20′ 59
B 52 2 12

b nearly 52 23 11 Sine 9 8988045
*p*D 3 2033995

1265″, 3 3 1022040
= 21′ 5″, 3 ☽'s parallax in long. from ☉
B 52 2 12

b correct 52 23 17 Sine 9 8988143

p 3

		p	3 5092025
		C	9 9390986
x nearly 2807″,4			3 4483011
= 46′ 47″	S		
☽'s true lat. = L 33 17	N		+
l nearly, viz. ☽'s viſ. lat. 13 30	S	Sine	7 5940588
		pD	3 2033995
		Co-ſine b	9 7855507
3″, 8			0 5830090
x nearly 46′ 47, 4			
+ 3, 8			
x correct 46 51, 2 ☽'s parallax in lat. from ☉			

Sine B	52° 2′12″	9 8967492
: Sine b	52 23 17	9 8988143
:: The moon's horiz. ſemi-diameter,	14′ 44″, 5 = 884″, 5	2 9466978
: Her augmented or viſible ſemi-diameter,	888, 8 = 14′ 48″, 8	2 9487629

By theſe reſults it appears that the foregoing *formulas* find the parallaxes and augmented ſemi-diameter of the moon to great exactneſs.

Let us now find the viſible difference of longitude between the center of the ſun and moon, at Greenwich, at 5^h. 29′ 57″, when the eclipſe begun there. Plate I, Fig. IV.

The

The ☉'s horizontal ſemi-diameter,	15′ 47″, 0
The ☽'s augmented ſemi-diameter,	14 48, 8
Sum,	30 35, 8
Subtract for inflection,	4, 5
Viſible diſtance of centers,	30 31, 3
	60
Hypotenuſe ☉☽	1831, 3
The ☽'s parallax in latitude from ☉,	46′ 51″, 2 S
The moon's latitude, —	33 17, 0 N
The ☽'s viſible latitude from ☉,	13 34, 2 S
	60
Side E☽	814, 2

Hypotenuſe ☉☽	1831, 3	
Side E☽ ±	814, 2	
Sum,	2645, 5	3 4225078
Difference,	1017, 1	3 0073637
		2 | 6 4298715
Side ☉E = the viſible diff. long. of ☉'s and ☽'s center,	1640, 3 = 27 20, 3	3 2149357

For the moon's true longitude according to obſervation.

From the ſun's true long. aug. $5^{D.}\ 5^{h.}\ 29'\ 57''$ $4^{S.}\ 13^{\circ}\ 9'\ 51'',0$

Subtract ☉'s and ☽'s viſible diff. long. by obſervation, 27 20, 3

Remains

Remains the ☽'s visible longitude nearly,	4 12 42 30, 7
Add the moon's parallax in longitude from the ☉.	+ 21 5, 3
The sum is the ☽'s true long. according to observ.	4 13 3 36, 0
The true diff. of long. of ☉ and ☽ according to observa.	6 15
	60
	375

Let us now find the requisites for $7^{h.}$ 11′ $33\frac{1}{2}$″ when the eclipse ended at Greenwich.

Elements for computing the parallaxes, &c. at $7^{h.}$ 11′ $33\frac{1}{2}$″

The sun's longitude,	$4^{s.}$ 13° 13′ 54″, 5
The moon's ecliptic longitude,	4 13 53 55, 6
The moon's latitude north,	28 40, 6
The sun's right ascension,	135 42 33
The right ascension of the mid-heaven,	243 35 55
Angle *p*PZ,	26 24 5
Complement,	63 35 55

Side PZ as before, as also the ☽'s horizontal parallax.*

From these elements are found

The altitude of the nonagesimal degree,	20° 11′ 5″
Angle P*p*Z,	126 12 38
The longitude of the nonagesimal degree,	$7^{s.}$ 6 12 38

Angle

* As the moon was near her apogee, the horizontal parallax altered so very little, in a few hours, that the same may here be taken for the end, as for the beginning. If the moon is not near her apogee or perigee, at the time of a solar eclipse, allowance should be made for the alteration of the horizontal parallax, between the beginning and end.

Angle Zp☽ = B,	82° 18′ 42″
The moon's parallax in longitude from the ſun,	18 25, 3
The moon's parallax in latitude from the ſun,	50 32, 5 S
The moon's augmented ſemi-diameter,	14 45, 1
The ſum of the ☉'s and ☽'s ſemi-diameters—4″,5 for inflection = ☉☽	1827,6″
The moon's viſible latitude from the ☉ = E☽	1311, 9 S
The viſible diff. of long. of the ☉'s & ☽'s centers = ☉E	1272, 4
	= 21′ 12″, 4
To the ſun's true longitude at $7^{h.}$ 11′ 33″½	$4^{s.}$ 13° 13′ 54″,5
Add the viſible diff. of long. of ☉ and ☽ by obſerv.	+ 21 12, 4
The ſum is the ☽'s viſible longitude nearly,	4 13 35 6, 9
Add the ☽'s parallax in long. from the ſun,	+ 18 25, 3
The ſum is the ☽'s true long. according to obſ.	4 13 53 32, 2
The true diff. of long. of ☉ and ☽ at the end by obſ.	39 37, 7
	60
	= 2377, 7
The true diff. by obſervation at the beginning,	+ 375, 0
The whole motion of the ☽ from the ☉ in the ecliptic by obſervation,	2752, 7

By Mayer's tables

The moon's long. at the beginning of the eclipſe,	$4^{s.}$ 13° 3′ 59″. 0
Ditto at the end,	4 13 53 55, 6
The difference = the moon's whole motion during the eclipſe,	49 56, 6

The

The ſun's motion for the ſame time,	—4′ 3,″ 5
The whole motion of the ☽ from the ☉ by Mayer's tables	45 53, 1
	60
	2753, 1

By this it appears, that the whole motion of the moon from the ſun in the ecliptic, by obſervation, differs but 0″, 4 from that given by the tables: Therefore, if we ſuppoſe the horary motions by theſe to be correct, the latitude will be nearly exact, the obſervations being allowed good.

For the time of the true conjunction of the ſun and moon according to obſervation.

The beginning of the eclipſe by obſ. at Greenwich,	$5^{h.}$ 29′ 57″
The end,	7 11 33½
The difference = the duration	1 41 36½
	60
	101
	60
	6096½

The whole motion of ☽ from the ☉ during the eclipſe,	2752″, 7	3 4397589
: The time of the duration,	6096½,	3 7850806
:: Diff. long. ☽ & ☉ at the beginning by obſ.	375, 0	2 5740313
: The time from the begin. to ecliptic conju.	830½	2 9193530
	= 13′ 50½″.	

To

To the time of the beginning of the eclipse by observ.	$5^{h.}\ 29'\ 57''$
Add	13 $50\frac{1}{2}$
The sum is the time of ecliptic conjunction by observ.	5 43 $47\frac{1}{2}$

SCHOLIUM.

From the observation of the beginning or ending of a solar eclipse, at a place, for which astronomic tables have been constructed, or, at a place, whose difference of longitude from that, for which the tables have been constructed, is accurately ascertained, the error in the moon's longitude as given by them, may be known, if they have given her latitude exact, or the error, if there be one, has been corrected by observation. For example, when the foregoing eclipse began at Greenwich, the moon's longitude, by Mayer's printed tables, was $4^{s.}\ 13°\ 3'\ 59''$, 0, but, deduced from the observations, it was but $4^{s.}\ 13°\ 3'\ 36''$, 0; the error of these tables, therefore, in the moon's longitude, at that time, was + 23'', supposing the latitude exact. By the observation of the end the error was 23'', 4.

Having found the time of the ecliptic conjunction of the sun and moon, at Greenwich, as deduced from the observations of the beginning and ending of the eclipse, we are next to find the conjunction at Cambridge, from the observations made there.

Let us assume the difference of meridians between Greenwich and Cambridge to be $4^{h.}\ 44'\ 25''$, then, at $11^{h.}\ 39'\ 23''$, A. M. when the eclipse began at Cambridge, it was $4^{h.}\ 23'\ 48''$, P. M. at Greenwich; and the sun's longitude and right ascension, and the moon's latitude and longitude were the same, at each place.

Having found these for Greenwich, at $5^{h.}\ 29'\ 57''$, P. M. it will be easy to obtain them for $4^{h.}\ 23'\ 48''$, answering to $11^{h.}$ $39'\ 23''$ at Cambridge, by the solar and lunar motions for $1^{h.}\ 6'$ $9''$, the difference between $5^{h.}\ 29'\ 57''$ and $4^{h.}\ 23'\ 48''$.

Elements for Cambridge at $11^{h.}\ 39'\ 23$, A. M.

The sun's longitude,	4s.	13°	7′	12″,5	
The moon's ecliptic longitude,	4	12	31	28, [illegible]	
The moon's latitude north,			36	16, 8	
The moon's horizontal parallax,			54	0, 5	
The sun's right ascension,		135	35	35	
The right ascension of the mid-heaven,		130	26	20	
Angle pPZ		139	33	40	
	=	40	26	20	
Complement		49	33	20	
The latitude of Cambridge,		42	23	28	N
Reduced to the center,		42	8	37	
Complement = PZ		47	51	23	

From these elements are found,

The altitude of the nonagesimal degree,		67	0	6	
Angle PpZ		31	30	11	
The longitude of the nonagesimal degree,	4	1	30	11	
Angle $Zp☽ = B$		11	1	17	
The moon's parallax in longitude from the sun,			9	36,8	
The moon's parallax in latitude from the sun,			20	49,9	S
The moon's augmented semi-diameter,			14	57,2	
The sum of the ☉'s and ☽'s semi-diameter — 4″,5 for inflection = ☉☽,			18	39,7	
The moon's visible latitude from the sun = E☽,			9	26,9	N

The

The visible diff. of long. of the ☉'s & ☽'s centers = ☉E 1589″,1
= 26′ 29″,1

From the sun's true longitude at Cambridge, at 11$^{h.}$ 39′ 23″,	4$^{s.}$ 13° 7 12, 5
Subtract ☉'s and ☽'s visible diff. long. by observation,	— 26 29, 1
	4 12 40 43, 4
Subtract the moon's parallax of longitude from ☉,	— 9 36, 8
The moon's true long. according to observa.	4 12 31 6, 6
The true diff. of long. of ☉ & ☽ according to observa.	36 5, 9
	60
	2165, 9

Elements for the end of the eclipse at Cambridge, at 2$^{h.}$ 45′ 9″, P. M.

The sun's longitude,	4$^{s.}$ 13° 14′ 37″,7
The moon's ecliptic longitude,	4 14 2 46, 7
The moon's latitude north,	27 51, 5
The sun's right ascension,	135 43 1
The right ascension of the mid-heaven,	177 0 16
Angle pPZ	92 59 44
	= 87 0 16
	Complement

From these elements are found,

The altitude of the nonagesimal degree,	53 7 38
Angle PpZ,	67 45 32
The longitude of the nonagesimal degree,	5 7 45 32

Angle

Angle Z*p* ☽ = B,	23°42′45″
The moon's parallax in longitude from the ſun,	17 31, 7
The moon's parallax in latitude from the ſun,	32 22, 5
The moon's augmented ſemi-diameter,	14 54, 7
The ſum of the ☉'s and ☽'s ſemi-diameters — 4″,5 for inflection = ☉☽,	1837, 2
The moon's viſible latitude from the ☉ = E☽,	271, 8
The viſible diff. of long. of ☉'s and ☽'s centers = ☉E	1817, 1
	= 30 17, 1
To the ſun's true longitude at Cambridge, at 2h. 45′ 9″,	4s. 13 14 37, 7
Add ☉'s and ☽'s viſible diff. long. by obſervation,	+ 30 17, 1
	4 13 44 54, 8
Add the moon's parallax of longitude from ☉,	+ 17 31, 7
The true long. of the moon according to obſ.	4 14 2 26, 5
The true diff. of long. of ☉ and ☽ according to obſerva.	47 48, 8
	60
	2868, 8
The true difference by obſervation at the beginning 11h. 39′ 23″, A. M.	2165, 9
The whole motion of ☽ from ☉ in the ecliptic by obſ.	5034, 7

By Mayer's tables,

The moon's long. at the beginning of the eclipſe,	4s. 12° 31′ 28″,1
Ditto at the end,	4 14 2 46, 7
Diff. = ☽'s whole motion in the ecliptic during the eclipſe,	1 31 18, 6

The

The ſun's motion for the ſame time,	7' 25'',2
The whole motion of ☽ from ☉ by Mayer's tables,	1 23 53, 4
	60
	83
	60
	5033, 4

By this it appears that the whole motion by obſervation differs but 1'',3 from that given by Mayer's tables.

The time of the duration of the eclipſe by obſervation was 11146''.

For the time of the true conjunction of the ſun and moon at Cambridge by obſervation.

The whole motion of ☽ from ☉ in the ecliptic during the eclipſe,	5034'',7	3 7019736
: The time of the duration,	11146	4 0471190
:: Diff. long. ☽ and ☉ at the begin. by obſerv.	2165, 9	3 3356384
: The time from the beginning to the ecliptic ☌ by obſervation,	4795	3 6807838
	= 79' 55''	
Add this time,	= 1$^{h.}$ 19 55	
To the time of the beginning by obſerva.	11 39 23	
The ſum is the time of ecliptic ☌ by obſerva.	0 59 18	
Time of ecliptic ☌ at Greenwich by obſerva.	5 43 47½	
Diff. = the diff. of meridians between Greenwich & Cambridge by obſerva.	4 44 29½	

Thus

Thus it appears, that according to the obſervations of this eclipſe made at Greenwich and Cambridge, the difference of meridians between thoſe places is $4^{h.}\ 44'\ 29\frac{1}{2}''$; ſo that the time that was aſſumed for the difference was very near the truth. If the difference of meridians, thus deduced, is in any caſe conſiderably different from that which was aſſumed, this reſult is to be conſidered as only the approximate difference, and is to be uſed as a new-aſſumed difference, from which deductions are to be made for the true. If the firſt reſult does not differ more than two or three minutes from the aſſumed difference of meridians, the ſame parallax in longitude and latitude may be uſed in the ſecond proceſs, which were found and uſed in the firſt; becauſe the right aſcenſion of the mid-heaven will not differ more than 6″ or 8″ from the firſt = the difference in the ſun's right aſcenſion, which, together with the ſmall difference in the moon's longitude and latitude, will make ſo trifling a difference in her zenith diſtance and parallactic angle, that the difference of parallaxes will be inconſiderable. All, therefore, that is neceſſary to be done, in the ſecond proceſs, is to find the ſun's longitude and the moon's latitude for the approximate or new aſſumed difference of meridians, from whence, with the parallaxes, we muſt deduce the difference of longitude between the ſun and moon, whereby the true conjunction will be obtained.

For illuſtration, let us take the foregoing obſervations of the ſolar eclipſe, and aſſume $4^{h.}\ 42'\ 25''$ for the difference of meridians between Greenwich and Cambridge.

According to this aſſumption, at $11^{h.}\ 39'\ 23''$, A. M. when the eclipſe began at Cambridge,

The

The ſun's longitude by the tables,	$4^{s.}\ 13^{\circ}\ 7'\ 7'',7$
The moon's ecliptic longitude,	4 12 30 29, 1
The moon's latitude,	36 22, 2
The ſun's right aſcenſion,	135 35 30
The right aſcenſion of the mid-heaven,	130 26 15
Angle pPZ	139 33 45
=	40 26 15
Complement	49 33 45
Hence	
The altitude of the nonageſimal degree,	67 0 7
Angle PpZ,	31 29 49
The longitude of the nonageſimal degree,	4 1 29 49
Angle Zp☽ = B,	11 0 40
The moon's parallax in longitude from the ſun,	9 36, 3
The moon's parallax in latitude from the ſun,	20 49, 8
☉ ☽ as before,	$1839'',7$
E☽ or the moon's viſible latitude from the ſun,	932, 4
The viſible diff. of long. of ☉'s and ☽'s centers = ☉E	1585, 9
	$= 26'\ 25'',9$
The ☽'s ecliptic long. by obſerva. according to the above aſſumption,	$4^{s.}\ 12^{\circ}\ 31\ \ 5,\ 5$
The true diff. of long. of ☉ and ☽ by obſervation according to the aſſumption,	36 2, 2
	60
	2162, 2

At the end of the eclipſe at Cambridge at $2^{h.}\ 45'\ 9''$ according to the above aſſumption,

The

The ſun's longitude,	4$^{s.}$ 13° 14′ 32″,9
The moon's ecliptic longitude,	4 14 1 47, 7
The moon's latitude,	27 56, 9
The ſun's right aſcenſion,	135 42 56
The right aſcenſion of the mid-heaven	177 0 11
Angle *p*PZ,	92 59 49
	= 87 0 11
Complement	2 59 49

Hence

The altitude of the nonageſimal degree,	53 7 40
Angle P*p*Z	67 45 30
The longitude of the nonageſimal degree,	5 7 45 30
Angle Z*p*☽ = B	23 43 42
The moon's parallax in longitude from the ſun,	17 31, 7
The moon's parallax in latitude from the ſun,	32 22, 4
⊙☽ as before,	1837″,2
E☽	265, 5
The viſible diff. of long. of ⊙'s and ☽'s centers = ⊙E	1817, 9
	= 30′ 17″,9
The moon's ecliptic long. by obſervation according to the above aſſumption,	4 14 2 22, 5
The true diff. of long. of ⊙ and ☽ by obſerva. at the end of the eclipſe, according to the aſſumption,	47 49, 6
	60
	2869, 6
The difference at the beginning as above,	2162, 2
The whole motion of ☽ from ⊙ accord. to this aſſum.	5031, 8

$5031'', 8 : 11146'' :: 2162'', 2 : 4789\frac{1}{2}'' = 1^{h.}\ 19'\ 49\frac{1}{2}''$

The beginning of the eclipse at Cambridge,	11	39	23
The ecliptic ☌ of ☉ and ☽ by observa. according to the foregoing assumption,	0	59	$12\frac{1}{2}$
Time of ☌ at Greenwich by observation,	5	43	$47\frac{1}{2}$
The difference of meridians by this assumption,	4	44	35

By this it appears, that the assumed difference of meridians, viz. $4^{h.}\ 42'\ 25''$, differs much from the truth : But the parallaxes resulting from this assumption, are so very near those resulting from the first, that it is evident they may be employed in the remaining part of the process, without causing any sensible error. Let $4^{h.}\ 44'\ 35''$, the difference of meridians now found, be used as a new-assumed difference, which will give the moon's latitude at the beginning of the eclipse at Cambridge $36'\ 16'', 5$, and at the end $27'\ 51'', 2$, and by a proper process we shall find the visible difference of longitude of ☉ and ☽ at the beginning $1589'', 3$, and the true difference $2165'', 6$; and at the end the visible difference $1817,'' 1$, and the true $2868'', 8$. Hence we find the time of ecliptic conjunction at Cambridge $0^{h.}\ 59'\ 17\frac{1}{2}''$, and the difference of meridians between Cambridge and Greenwich $4^{h.}\ 44'\ 30''$, but half a second different from what it was at first found.

If instead of finding the difference of meridians at once, by the conjunction at each place, any one chuses to find it by the beginning and end separately, he may easily do it.

 At

At the beginning of the foregoing eclipse at Greenwich, it appears, that the moon's ecliptic longitude by observation was $4^{s.}\ 13^\circ\ 3'\ 36''$, 0, but when it began at Cambridge, her longitude by observation was but $4^{s.}\ 12^\circ\ 31'\ 6''$. The difference is $32'\ 29''$, $4 = 1949''$, 4. Let us find how long the moon was in passing over this portion of the ecliptic, thus,

The ☽'s horary mot. in long. $29'29''$,5 =	$1769''$,5	3 2478506
: 1 hour,	3600	3 5563025
::	1949, 4	3 2899010
:	3966	3 5983529
	$= 1^{h.}\ 6'\ 6''$	

By this it appears, that it was $1^{h.}\ 6'\ 6''$ after the eclipse began at Cambridge, before the moon had the same longitude, as when the beginning was observed at Greenwich : Therefore, to $11^{h.}\ 39'\ 23''$, A. M. add $1^{h.}\ 6'\ 6''$; the sum $0^{h.}\ 45'\ 29''$, shews the time at Cambridge, when she had the same longitude as at Greenwich at $5^{h.}\ 29'\ 57''$; and the difference $4^{h.}\ 44'\ 28''$ is the difference of meridians in time, between those two places as deduced from the observations of the beginning of this eclipse. By a similar process, we find the difference resulting from the observations of the end to be $4^{h.}\ 44'\ 31\frac{1}{2}''$. The mean is $4^{h.}\ 44'\ 29\frac{3}{4}''$.

Another solar eclipse, the observations of which we make use of, to determine the difference of meridians between Greenwich and Cambridge, is that of June 24, 1778. As the clouds were troublesome, at that time, at Cambridge, and consequent-

ly

ly the obſervations ſomewhat uncertain, we may take the obſervation of the end of the eclipſe made at Chelſea, by the Rev. Mr. Payſon, who had a very favourable time. And as Mr. Payſon and I have, by terreſtrial meaſurement, made with much preciſion, found Chelſea to be 26″ in time eaſt of Cambridge, this obſervation is the ſame to our purpoſe, as if made in Cambridge.

The beginning of this eclipſe was obſerved by the Rev. Dr. Nevil Maſkelyne, at the Royal Obſervatory at Greenwich, at $3^{h.}\ 40'\ 11''$, and the end at $5^{h.}\ 25'\ 12''$ apparent time.* At Chelſea, the end was obſerved by the Rev. Phillips Payſon, at his own houſe, at $11^{h.}\ 38'\ 23''$, A. M. apparent time.

At the Royal Obſervatory at Greenwich, at $3^{h.}\ 40'\ 11''$ apparent time.

The ſun's longitude by Mayer's tables,	$3^{s.}\ 3^{\circ}\ 4'\ 2'',0$
The moon's ecliptic longitude,	3 3 6 32, 0

The

* I am indebted to Mr. De La Lande, a celebrated member of the Royal Academy of Sciences at Paris, for the European obſervations of this eclipſe; who, in a very obliging manner, in a letter of November 30, 1781, communicated them to me. They are as follow:

	At Oxford,	Greenwich,	Deptford,	Stockholm,	Paris,
Beg.	$3^{h.}\ 33'\ 44''$	$3^{h.}\ 40'\ 11''$	$3^{h.}\ 40'\ 12''$	$5^{h.}\ 4'\ 19''$	$3^{h.}\ 53'\ 15''$ or $13''$
End.	5 19 48	5 25 12	5 25 11½	6 13 25	

	Marſeilles,	Padua,	Milan,	Cadiz,	Toulouſe,
Beg.	4 12 0	4 41 46	4 29 9	3 18 53	3 52 27 or 24 or 22
End.	6 1 46	6 21 41	6 12 0	5 26 25	

As the beginning only was obſerved at Paris, I have taken the obſervations made at Greenwich, where the end as well as the beginning of the eclipſe was ſeen.

The moon's latitude north increaſing,	19′ 20″,7
The ſun's horary motion,	2 23, 0
The moon's horary motion in long. in the ecliptic,	37 36, 3
The moon's horary motion in latitude,	3 9, 8
The moon's horizontal parallax,	61 7, 6
The ſun's horizontal parallax,	8, 4
The ſun's right aſcenſion,	93° 20 36
The right aſcenſion of the mid-heaven,	148 23 21
Angle *p*PZ,	121 36 39
	= 58 23 21
Complement	31 36 39
The ſun's ſemi-diameter,	15 47
The moon's horizontal ſemi-diameter,	16 40, 3
The obliquity of the ecliptic,	23 28 6
PZ, &c. as before,	

Hence

The altitude of the nonageſimal degree,	54 13 45
Angle P*p*Z,	41 5 7
The longitude of the nonageſimal degree,	4 11 5 7
Angle Z*p*☽ = B,	37 58 35
The moon's parallax in longitude from the ſun,	30 47, 6
The moon's parallax in latitude from the ſun,	35 50, 1
The moon's augmented ſemi-diameter,	16 51, 8
The ſum of ☉'s & ☽'s ſemi-diam.—4″,5 for infl. = ☉☽,	1954″,3
The moon's viſible lat. from the ſun = E☽	989, 4
The viſible diff. of long. of ☉'s and ☽'s centers ☉E,	1635, 3
	= 28 5″,3
The moon's ecliptic long. by obſervation,	3ˢ· 3° 6 44, 3

At

At the Royal Obſervatory at Greenwich, at $5^{h.}$ 25′ 12″ apparent time.

The ſun's longitude,	$3^{s.}$ 3°	8′	12″,2	
The moon's ecliptic longitude,	3 4	12	21, 0	
The moon's latitude north,		42	52, 8	
The ſun's right aſcenſion,	93	25	8	
The right aſcenſion of the mid-heaven,	174	43	8	
Angle pPZ,	95	16	52	
	= 84	43	8	
Complement	5	16	52	

Hence

The altitude of the nonageſimal degree,		46	11	19
Angle PpZ		59	45	50
The longitude of the nonageſimal degree,	4	29	45	50
Angle Zp ☽ = B,		55	33	29
The moon's parallax in longitude from the ſun,			36	33, 5
The moon's parallax in latitude from the ſun,			42	20, 7
The moon's augmented ſemi-diameter,			16	47, 8
The ſum of ☉'s & ☽'s ſemi-diam.—4″,5 for infl. = ☉☽,				1950″,3
The moon's viſible lat. from the ſun = E ☽,				1047, 9
The viſible diff. of long. of ☉'s and ☽'s centers = ☉E,				1644, 9
				= 27′ 24″, 9
The moon's ecliptic long. by obſervation,	$3^{s.}$ 4°	12		10, 6

Hence it appears, that the motion of the moon by obſervation, during the eclipſe, with reſpect to the ecliptic, was 1° 5′ 26″,3; but, by Mayer's tables, it was 1° 5′ 49″. Suppoſing then the horary motion by the tables to be true, as is moſt probable, we may conclude, that there is an error in the moon's latitude,

latitude, as given by them, the correction of which may be found, in the manner following:

The ☽'s longitude at the beginning, per tables,	3s. 3° 6′ 32″,0
The ☽'s parallax in longitude from ☉	— 30 47, 6
	3 2 35 44, 4
The ☽'s longitude at the end per tables,	3 4 12 21, 0
The ☽'s parallax in longitude from ☉	— 36 33, 5
	3 3 35 47, 5
Subtract	3 2 35 44, 4
Difference	1 0 3, 1
Subtract ☉'s motion during the eclipse,	4 10, 2
Remains ☽'s visible motion from ☉ per tables,	55 52, 9
	60
	3352, 9
The ☽'s visi. lat. from ☉ by calculation at beginning,	989″,4
At the end,	1047, 9
The ☽'s visible motion in latitude from the ☉,*	58, 5

In plate I. fig. I. let E☉C be a portion of the ecliptic § = 3352″,9 the moon's visible motion from the sun, during the eclipse.

* The moon's visible motion as it arises from her horary motion and parallaxes in latitude, is not affected by the small error in the latitude given by the tables.

§ See note, page 17.

eclipse. Let ☽E be = the moon's visible latitude from the sun, at the beginning of the eclipse, and CL the same at the end. Let ☽M be drawn parallel to E⊙C; then, ML = 58″.5 will be the moon's visible motion in latitude from the sun, during the eclipse, and M☽L, the visible angle of the moon with the sun in the ecliptic.* Let ☽ be the distance of the ⊙'s and ☽'s centers, at the beginning of the eclipse, and ⊙L the same at the end; then the point at ⊙ will be the place of the ecliptic conjunction; and the line ⊙D, perpendicular to the ecliptic, and cutting the moon's visible path ☽L in D, will be the moon's visible latitude from the sun, at the time of the ecliptic conjunction; and the line ⊙N, perpendicular to the visible path, and cutting it in N, will be the least distance of centers.

☽M	3352″,9	3	5254206
: ML	58, 5	1	7675269
:: Radius		10	
: Tangent angle M☽L,	1° 0′ 2″	8	2421063
Sine angle M☽L,	1 0 2	8	2420401
: ML	58, 5	1	7675269
:: Radius		10	
: ☽L	3353, 4	3	5254868
☽L	3353″,4	3	5254868
: ☽⊙+L⊙	3904, 6	3	5915796
:: ☽⊙—L⊙	4, 0	0	6020600
: Difference ☽N and LN	4, 6	0	6681528

* The true side ML is so short in this small figure, that it was necessary to increase it for the sake of illustration; but every one knows that the calculations are not affected by it, the true length being used in them.

Mo. Bot. Garden,
1887.

½ ☽L	1676″,7		
½ difference ☽N and LN	+— 2, 3		
☽N	1679, 0		
LN	1674, 4		
☽⊙	1954, 3	3	2909912
: Radius		10	
:: ☽N	1679, 0	3	2250507
: Sine angle ☽⊙N	59°13′ 9″	9	9340595
Angle N☽D = M☽L	+ 1 0 2		
Angle ☽⊙D = ☽⊙F	60 13 11		
	90		
Angle ☽⊙E	29 46 49		
Radius		10	
: ☽⊙	1954″,3	3	2909912
:: Sine angle ☽⊙E	29°46′49″	9	6959990
: E☽	970, 5	2	9869902
☽'s vifible lat. from ⊙ =	16′ 10, 5 S		
From ☽'s parallax in lat. from ⊙	35 50, 1		
Sub. ☽'s vifi.lat.from⊙now found	16 10, 5		
Remains ☽'s correct latitude,	19 39, 6 N		
☽'s lat. by Mayer's tables,	19 20, 7 N		
Error of the tables in ☽'s lat.	— 18, 9*		

* As the time both of the beginning and end of the eclipfe is ufed in deducing this error, there is no need of finding CL, which would give the fame.

Thus it appears, by the Greenwich obſervations of the beginning and end of this eclipſe, that the latitude of the moon, given by Mayer's tables, is 18″, 9 too ſmall,* which correction, being applied, will give her latitude at the beginning 19′ 39″, 6, and at the end 25′ 11″, 7. Hence the viſible difference of longitude, at the beginning, was 28′ 16″, 3, and at the end 27′ 36″, 7; and the true longitude by obſervation $3^{s.}$ 3° 6′ 33″, 3 and $3^{s.}$ 4° 12′ 22″, 4, the difference being 1° 5′ 49″, as by the tables. The true difference of longitude between the ſun and moon, at the beginning, was 151″, 3, the moon's longitude being the greateſt: Therefore, ☽'s horary motion from ☉ 2113″,3 : 1 hour = 3600″ :: 151″,3 : 257$\frac{3}{4}$″ = 4′ 17$\frac{3}{4}$″; which being ſubtracted from $3^{h.}$ 40′ 11″ (the obſerved time of the beginning of the eclipſe at Greenwich) becauſe the moon had really paſſed the conjunction, leaves $3^{h.}$ 35′ 53$\frac{1}{4}$″ for the apparent time of the true ecliptic conjunction.

Let us now aſſume $4^{h.}$ 44′ 4″ for the difference of meridians between Greenwich and Chelſea, and find the elements for Chelſea, at the end of the eclipſe, viz. At $11^{h.}$ 38′ 23″, anſwering to $4^{h.}$ 22′ 27″ at Greenwich, according to this aſſumption.

At Chelſea at $11^{h.}$ 38′ 23″, A. M. apparent time.

The ſun's longitude,	$3^{s.}$	3°	5′	42″,8
The moon's ecliptic longitude,	3	3	33	1, 8

The

* By the Oxford obſervations of the beginning and end of this eclipſe, the error in latitude, in Mayer's tables, was — 20, 6, differing but 0, 7 from the error found by the Greenwich obſervations.

The moon's lat. corrected by the Greenwich observa.			21	53, 2
The moon's horizontal parallax,			61	10, 0
The sun's right ascension,		93	22	25
The right ascension of the mid-heaven		87	58	10
Angle pPZ,		177	58	10
		= 2	1	50
Complement		87	58	10
The latitude of Chelsea,		42	25	11
Reduced to the center,		42	10	20
Complement = PZ		47	49	40

Hence

The altitude of the nonagesimal degree,		71	17	6
The longitude of the nonagesimal degree,	2	28	24	40
Angle Zp☽ = B		5	8	21
The moon's parallax in longitude from the sun,			5	15, 8
The moon's parallax in latitude from the sun,			19	32, 6
The sum of ☉'s & ☽'s semi-diam.—4″,5 for infl. = ☉☽,				1959″,8
The moon's visible latitude from the sun,				140, 6
The visible diff. of long. of ☉'s and ☽'s centers = ☉E				1954, 7
				= 32′ 34″,7
The moon's ecliptic long. by observation,		3ˢ· 3°	33	1, 7
The true diff. of long. of ☉ and ☽ according to the assumption,			27	18, 9
				= 1638″,9

☽'s horary motion from ☉ 2113″, 3 : 1 hour = 3600″, :: 1638″, 9 : 2792″ = 46′ 32″. Subtract 46′ 32″ from 11ʰ· 38′ 23″, the time of the end of the eclipse at Chelsea, and the remainder 10ʰ· 51′ 51″, A. M. will be the time when the true

true ecliptic conjunction happened. This subtracted from $3^{h.}$ $35' 53\frac{1}{4}''$, P. M. the time of the true ecliptic conjunction at Greenwich, leaves $4^{h.}$ $44'$ $2\frac{1}{4}''$ for the difference of meridians between these two places. To this add 26'', the difference of meridians between Cambridge and Chelsea; the sum, $4^{h.}$ $44'$ $28\frac{1}{4}''$ will be the difference between Cambridge and Greenwich, by the observations of this eclipse.

Deductions from the observations of a transit of Mercury, November 5, 1743, for determining the difference of meridians between Paris* and Cambridge.

At Paris, November 5, 1743, a transit of Mercury was observed by

		1st. inter. contact. Apparent time.
Mr. Maraldi,	At the Royal Observatory,	$8^{h.}$ 40' 46''
Mr. Cassini, jun.	At the Royal Observatory,	8 40 34
The Abbe de la Caille, at College Mazarin,		8 40 38
Mr. Cassini, sen. at Thury,		8 40 31
	The mean,	8 40 $37\frac{1}{4}$

	2d. inter. contact.	2d. exter. contact.
Mr. Maraldi,	$1^{h.}$ 10' 17''	1 12 18
Mr. Cassini, jun.	1 10 26	1 12 24
The Abbe de la Caille,	1 10 3	1 11 58
Mr. le Monnier, jun. near Port St. Honoré,	1 9 $54\frac{1}{2}$	1 12 2

Mr.

* A bad state of the atmosphere prevented this transit from being observed at Greenwich.

Mr. Caffini, fen.	$1^{h.}$ 10′ 28″	*
Mean,	1 10 $13\frac{1}{3}$	1 12 $10\frac{1}{2}$

Hence it appears, that at the egrefs, Mercury was about 1′ 57″ in making his tranfit acrofs the fun's limb, the half of which, viz. $58\frac{1}{2}$″, added to the time of the fecond internal contact, will give $1^{h.}$ 11′ 12″, P. M. for the time of the central contact, at the egrefs; and, fubtracted from the time of the firft internal contact, will give the central contact at the ingrefs $8^{h.}$ 39′ $38\frac{3}{4}$″, A. M.

N. B. The place where Mr. Caffini, fen. obferved is 6″ in time eaft of the meridian of the Royal Obfervatory; the place where Mr. le Monnier, jun. obferved, 2″ weft. The times obferved by them are here adjufted to the meridian of the Obfervatory. The place where the Abbe de la Caille made his obfervations is fo near to the meridian of the Royal Obfervatory, that the difference in time is imperceptible.

At $8^{h.}$ 39′ $38\frac{3}{4}$″, A. M. apparent time, at the Royal Obfervatory of Paris.

The fun's longitude,	$7^{s.}$ 12° 32′ 57″,205
Mercury's geocentric ecliptic longitude,	7 12 45 5, 688
Mercury's geocentric lat. fouth decreafing,	10 48, 165
The fun's right afcenfion,	220 5 40
The right afcenfion of the mid-heaven,	170 0 21
Angle pPZ,	99 59 39

= 80

* Mr. Caffini, fen. was doubtful of the fecond external contact; it is therefore omitted.

		= 80° 0′21″
Complement		9 59 39
Mercury's diſtance form the earth,	log.	4 829651
: The ſun's diſtance from the earth,	log.	4 995787
:: The ſun's horizontal parallax, 8″,58	log.	0 933487
: Mercury's horizontal parallax, 12, 578		1 099620

Mercury's horizontal parallax from the ſun,	3″,998
The ſun's ſemi-diameter,	16′ 11, 7
Mercury's ſemi-diameter,	5, 1
The ſun's horary motion,	2 30, 7
Mercury's geocen. horary mot. in the ecliptic retrog.	3 22, 12
Mercury's mot. upon ⊙'s diſc with reſpect to the eclip.	5 52, 82
Mercury's horary motion in latitude geocentric,	51, 7
Latitude of the Royal Obſervatory at Paris,	48° 50 14
Reduced to the center,	48 35 26
Complement = PZ	41 24 34

Hence

The altitude of the nonageſimal degree,	50 2 38
The longitude of the nonageſimal degree,	5ˢ 28 11 44
Angle Z*p*☿ = B,	44 33 22
Mercury's parallax in longitude from the ſun,	2, 151
Mercury's parallax in latitude from the ſun,	2, 574
The ſun's ſemi-diameter = ⊙☿	971, 7
Mercury's viſible lat. from the ſun's center = E☿	650, 739
The viſi. diff. of long. of ⊙'s and ☿'s centers = ⊙E,	721, 484
	= 12′ 37, 434
⊙'s longitude,	7 12 32 57, 205

Add

Add visi.diff.long.of ☉'s & ☿'s cent. ☿ being retro.	+ 12' 1'',4
	7$^{s.}$ 12° 44 58, 605
Mercury's parallax in longitude from the sun,	— 2, 151
Mercury's true long. by observation,	7 12 44 56, 454
The true diff.long.☉'s & ☿'s cen.by obs.at 8$^{h.}$ 39' 38¼'',	11 59, 249
	60
	719, 249

N. B. The above references are to Plate I. Fig. I. and IV. ☽ being supposed changed for ☿. The various processes are similar to those made in the foregoing solar eclipses.

At 1$^{h.}$ 11' 12'' the time of the central contact of ☿ at the egress.

The sun's longitude,	7$^{s.}$ 12° 44' 19'',258
Mercury's geocentric ecliptic longitude,	7 12 29 50, 909
Mercury's geocentric latitude south,	6 54, 174
The sun's right ascension,	220 16 58
The right ascension of the mid-heaven,	238 4 58
Angle *p*PZ	31 55 2
Complement	58 4 58

Hence

The altitude of the nonagesimal degree,	24 16 35
The longitude of the nonagesimal degree,	7 1 43 37
Angle Z*p*☿ = B,	10 46 13
Mercury's parallax in longitude from the sun,	0, 307

Mercury's

Mercury's parallax in latitude from the ſun,	3″,647
☉ ☿ as before,	971, 7
Mercury's viſible lat. from the ſun's center = E ☿	417, 821
The viſible diff. of long. of ☉'s and ☿'s centers = ☉E	877, 284
	= 14′ 37, 284
Mercury's true ecliptic long. by obſervation,	7ˢ· 12° 29 41, 667

Hence it appears, that Mercury's motion in geocentric longitude in the ecliptic, by obſervation, from his central contact at the ingreſs, to his central contact in the egreſs, was 15′ 14″, 787. According to the horary motion in the elements, from whence the calculations were made, it was 15′ 14″, 779. We may therefore take the motion given in the elements, as the true, and ſay, 5′ 52″, 82 = 352″, 82 Mercury's horary motion upon the ſun's diſc with reſpect to the ecliptic : 1 hour = 3600″ :: 719″, 249 the true difference of longitude of ☉'s and ☿'s centers at the central contact at the ingreſs : 7339″ = 2ʰ· 2′ 19″. This added to 8ʰ· 39′ 38¼″, the time of Mercury's central contact at the ingreſs, will give 10ʰ· 41′ 57¼″, A. M. apparent time, for the true ecliptic conjunction, by obſervation.

The ſame tranſit was obſerved by Profeſſor Winthorp,* at Cambridge, who ſaw the ſecond internal contact at 8ʰ· 17′ 5″,

* Profeſſor Winthrop, in a letter to Dr. Bliſs, Aſtronomer Royal, dated 20th June, 1763, and publiſhed in vol. LIX, of the Philoſophical Tranſactions, communicates his obſervations of this tranſit, with the expreſs deſign of ſettling the longitude of Cambridge, by comparing them with the European ones ; and he gives it as his opinion, that it might thereby be determined with more exactneſs, than by any obſervations that had been made uſe of, for that purpoſe.

A. M. apparent time, and the second external contact at $8^{h.}$ 18′ 58″; which makes the contact of Mercury's center, at the egress, at $8^{h.}$ 18′ 1½″, A. M.

Suppose the difference of meridians between Paris and Cambridge to be $4^{h.}$ 53′ 45″, then it was $1^{h.}$ 11′ 46½″, P. M. at Paris, when it was $8^{h.}$ 18′ 1½″, A. M. at Cambridge.

Elements at $1^{h.}$ 11′ 46½″, P. M. at Paris, answering to $8^{h.}$ 18′ 1½″, A. M. at Cambridge.

The sun's longitude,	$7^{S.}$ 12° 44′ 20″, 701
Mercury's geocentric ecliptic longitude,	7 12 29 48, 968
Mercury's geocentric latitude south,	6 53, 679
The sun's right ascension,	220 17 0
The right ascension of the mid-heaven,	164 47 22
Angle *p*PZ,	105 12 38
	= 74 47 22
Complement	15 12 38
PZ, as before,	47 51 23

Hence

The altitude of the nonagesimal degree,	57 27 17
The longitude of the nonagesimal degree,	4 28 4 43
Angle Z*p* ☿ = B,	74 25 5
Mercury's parallax in longitude from the sun,	3, 246

Mercury's

He informs Dr. Bliss, that his clock was adjusted by correspondent altitudes of the bright star of Aries, taken the night before the transit, with a quadrant of two feet radius; and on the day of the transit, by correspondent altitudes of the sun; all which agreed within 5″; and that he allowed for the difference of the sun's declination morning and afternoon.

Mercury's parallax in latitude from the ſun,	2″,154
☉☿,	971, 7
Mercury's viſi. lat. from the ſun's center = E☿,	415, 833
The viſi. diff. of long. of ☉'s and ☿'s centers = ☉E,	878, 227
	= 14′ 38, 227
From the ſun's longitude,	7ˢ· 12° 44 20, 701
Subtract the viſi. diff. of long. of ☉'s & ☿'s centers,	14 38, 227
	7 12 29 42, 474
Subtract ☿'s parallax in longitude from ☉,	3, 246
Remains ☿'s geocent. eclip. long. by obſerv. accord. to the aſſumed diff. of meridians,	7 12 29 39, 228
The true diff. long. ☉'s & ☿'s cent. by obſerva. at 8ʰ· 18′ 1½″, A. M.	14 41, 473
	60
	881, 473

352″, 82 : 3600″ :: 881″, 473 : 3994″ = 2ʰ· 29′ 54″.

Therefore,

From the time of ☿'s central contact by obſervation at Cambridge, at the egreſs,	8ʰ· 18′ 1½″, A.M.
Subtract	2 29 54
Rem. the time of the true ecliptic conj. by obſ.	5 48 7½, A. M.
The time of the true ecliptic conjunction at Paris by obſervation,	10 41 57¾, A. M.
Difference = the difference of meridians between Paris and Cambridge,	4 53 50¼

H 2 Subtract

Sub. the diff. of merid. betw. Paris & Greenwich,	— 9′ 16″, A.M.
Remains the difference of meridians between Greenwich and Cambridge,	4h. 44 34¼
The diff. by the obfervations of the folar eclipfe of Auguft 5, 1766,	4 44 29½
Do. by the obf. of the fol. eclipfe of June 24, 1778,	4 44 28¼
The mean	4 44 30⅔
Therefore, avoiding fractions, the difference of meridians may be called	4 44 31 ‡

I

‡ In a letter to the prefent Aftronomer Royal, publifhed in the volume of the Philofophical Tranfactions for 1781, I made the difference of meridians between Cambridge and Greenwich, by the folar eclipfe of Aug. 1766, to be 4h. 44′ 22″; and by the tranfit of Venus of June, 1769, to be 4h. 44′ 12″, comparing Mr. Hitchins's obfervation of the internal contact only, with Dr. Winthorp's. The mean of thefe two refults, viz. 4h. 44′ 17″, I gave as the true difference. But as the fun was low, when the obfervations of the tranfit were made at Greenwich, which caufed an uncertainty attending them, not experienced where the altitude was confiderable and the atmofphere clear, I have fuppofed it not expedient to make ufe of the refult from this phenomenon, in the foregoing paper.

In making my deductions from the folar eclipfe of 1766, in the above appendix, I have taken the mean between the time of the obfervations of the Aftronomer Royal, and of his affiftant; whereas, in the former calculations, I took thofe only of the Aftronomer Royal. I have alfo ufed 42° 23′ 28″, for the latitude of Cambridge, as determined by Profeffor Williams, inftead of 42° 25′; and with thefe alterations, having carefully gone over the work anew, I have found the difference of meridians, from this eclipfe, 4h. 44′ 29½″, inftead of 4h. 44′ 22″.

The deductions from the tranfit of Mercury, and the folar eclipfe of 1778, were not made, when the above letter was written.

I fuppofed it proper to add this note, to fhew the reafon of the difference between the refult in this paper, and that in the letter publifhed in the Philofophical Tranfactions.

I have been particular, in this appendix, in putting down the deductions from the obſervations which I have made uſe of, in ſettling the longitude of Cambridge from Greenwich, that any perſons, who may meet with this paper, and are able to go thro' this kind of calculation, may ſee what ſtreſs is to be laid upon the determinations. If the deductions are right, the near agreement between the three reſults is a ſtrong evidence of the goodneſs of the obſervations, and the dependence that may be made upon the mean reſult, for the difference of meridians between Greenwich and Cambridge; which, perhaps, is now aſcertained to as great exactneſs as the difference between almoſt any two places, where terreſtrial meaſurement has not been made uſe of.

J. W.

II. *A Memoir on the Latitude of the University at Cambridge: With Observations of the Variation and Dip of the Magnetic Needle.* By SAMUEL WILLIAMS, *F. A. A. Hollis Professor of Mathematics and Natural Philosophy in the University.*

I. THE latitude of Cambridge has generally been supposed to be 42° 25′ north. I cannot find how early, by what observer, or with what instruments it was determined. The earliest observations at Cambridge of which I can find any account, were those of eclipses made by Mr. *Thomas Brattle*, mentioned in *the Philosophical Transactions* for 1704, No. 292. p. 1630. The first of these was of a solar eclipse, June 12, 1694. And he there informs us, that in his calculations, the latitude of *Boston* was allowed to be 42° 25′. This has been universally received as the latitude ever since that time, and probably for many years before. As the ancient instruments belonging to the College were but small, I was desirous to examine this matter with all the accuracy I could. With this view I made the following observations. They were taken in the Philosophy-Chamber in Harvard-Hall, with an astronomical quadrant of two feet and an half radius, made by *Sissons*.

I. The

1. The latitude of the Univerſity at Cambridge, computed from obſervations of the meridian altitude of the ſun's upper limb.

Time.	Obſervation of the meridian altitude ☉'s upper limb.	Refraction.	☉'s Semidiameter.	Parallax.	☉'s Declination South.	Latitude of the Univerſity.
1782.						
Oct. 9	41° 24′ 30″	1′ 15″	16′ 5″,0	6″	6°29′35″	42° 23′ 21″
10	41 1 39	1 16	16 5, 3	6	6 52 23	42 23 25,3
11	40 39 3	1 17	16 5, 5	6	7 15 5	42 23 20,5

By a mean of theſe obſervations the latitude is 42° 23′ 22″,3

2. The latitude of the Univerſity computed from obſervations of the meridian altitude of ſtars near the Equator.

Obſervations of the meridian altitude of

Time.	δ In the wing of the *Eagle*.	π In the ſhoulder of *Antinous*	θ In the hand of *Antinous*.	β In the ſhoulder of *Aquarius*.	α In the ſhoulder of *Aquarius*.	γ In the Arm of *Aquarius*.
1782.						
Oct. 9	50°19′ 9″	48°5′ 35″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
12	50 19 51	48 5 57	46 10 34			
23		48 5 48	46 10 50			
Nov. 1			46 10 33			
3				41 7 8	46 15 45	45 9 35
4				41 6 53	46 15 33	45 9 20
5				41 6 53	46 15 34	45 9 18
Mean,	50 19 30	48 5 46,6	46 10 39	41 6 58	46 15 37,3	45 9 24,3

Calculations.

δ in the wing of the *Eagle*.

Mean of merid. altitudes taken Oct. 9, 12, 1782,		50°19′ 30″
Refraction by De la Caille's tables,	—	55
True meridian altitude,		50 18 35
Declin. N. Jan. 1, 1782, by *Connoi. des Temps*, 1782,		2 41 55

Increaſe

Increaſe of declination in 9, 5 months,	+			5″,1
Aberration,	+			8, 6
Nutation,	—			8, 6
Apparent declination N. Oct. 11, 1782,		2°	42′	0, 1
Complement of the latitude,		47	36	34, 9
Latitude,		42	23	25, 1

π in the ſhoulder of *Antinous*,

Mean of merid. altitudes taken Oct. 9, 12, 28, 1782,		48	5	47
Refraction,	—		1	0
True meridian altitude,		48	4	47
Declin. N. Jan. 1, 1782, by *Connoi. des Temps*, 1782,		0	28	4
Increaſe of declination in 9, 5 months,	+			6, 7
Aberration,	+			7, 5
Nutation,	—			8, 3
Apparent declination N. Oct. 16, 1782,		0	28	9, 9
Complement of the latitude,		47	36	37, 1
Latitude,		42	23	22, 9

θ in the hand of *Antinous*.

Mean of meridian altitudes taken Oct. 12, 23, and November 1, 1782,		46	10	39
Refraction,	—		1	4
True meridian altitude,		46	9	35
Declin. S. Jan. 1, 1782, by *Connoi. des Temps*, 1782,		1	26	57
Decreaſe of declination in 9, 5 months,	—			7, 8
Aberration,	—			6, 3
Nutation,	+			8, 0
Apparent declination S. Oct. 22, 1782,		1	26	50, 9
Complement of the latitude,		47	36	25, 9
Latitude,		42	23	34, 1

β in

β in the shoulder of *Aquarius*.

Mean of merid. altitudes taken Nov. 3, 4, 5, 1782,	41°	6′	58″	
Refraction,	—	1	16	
True meridian altitude,	41	5	42	
Declin. S. Jan. 1, 1782, by *Connoi. des Temps*, 1782,	6	30	59	
Decrease of declination in 10 months,	—		12,	5
Abberation,	—		3,	5
Nutation,	+		6,	3
Apparent declination S. Nov. 4, 1782,	6	30	49,	3
Complement of the latitude,	47	36	31,	3
Latitude,	42	23	28,	7

α in the shoulder of *Aquarius*.

Mean of merid. altitudes taken Nov. 3, 4, 5, 1782,	46	15	37	
Refraction,	—	1	4	
True meridian altitude,	46	14	33	
Declin. S. Jan. 1, 1782, by *Connoi. des Temps*, 1782,	1	22	5	
Decrease of declination in 10 months,	—		14,	3
Aberration,	—		5,	4
Nutation,	+		5,	2
Apparent declination S. Nov. 4, 1782,	1	21	50,	5
Complement of the latitude,	47	36	23,	5
Latitude,	42	23	36,	5

γ in the arm of *Aquarius*.

Mean of merid. altitudes taken Nov. 3, 4, 5, 1782,	45	9	24	
Refraction,	—	1	6	
True meridian altitude,	45	8	18	
Declin. S. Jan. 1, 1782, by *Connoi. des Temps*, 1782,	2	28	33	
Decrease of declination in 10 months,	—		14,	8

Aberration,	—			5″
Nutation,	+			4, 6
Apparent declination S. Nov. 4, 1782,		2°	28′	17, 8
Complement of the latitude,		47	36	35, 8
Latitude,		42	23	24, 2

The latitude by the meridian altitude of

δ in the *Eagle*,	42	23	25, 1
π in *Antinous*,			22, 9
θ in *Antinous*,			34, 1
β in *Aquarius*,			28, 7
α in *Aquarius*,			36, 5
γ in *Aquarius*,			24, 2
By a mean of these observations the latitude is	42	23	28, 6

3. The latitude of the University computed from observations of the meridian altitude of the pole-star.

Observations of the meridian altitude of the pole-star, below the pole.

1783.	May	27	40°	33′	22″
		28	40	33	25
		29	40	33	35
	June	5	40	33	22
Mean altitude,			40	33	26

CALCULATION.

Mean of merid. altitudes taken May 27, 28, 29, and June 1, 1783. Below the pole.		40	33	26
Refraction by De la Caille's tables,	—		1	17
True meridian altitude,		40	32	9
Declin. N. Jan. 1, 1782, by *Connoi. des Temps*, 1782,		88	8	28

Increase

Increaſe of declination in one year,	+	19″,6
Increaſe of declination in 5 months,	+	8, 2
Aberration,	—	17, 0
Nutation,	+	2, 5
Apparent declination N. June 1, 1783,		88° 8′ 41, 3
Diſtance from the pole,		1 51 18, 7
Latitude,		42 23 27, 7

From theſe calculations the latitude computed

1. From obſervations of the ſun, is	42 23 22, 3
2. From obſervations of ſix ſtars near the Equator,	42 23 28, 6
3. From obſervations of the pole-ſtar,	42 23 27, 7

In making the above obſervations I found it much eaſier to note the biſection of a ſtar by the wire of the teleſcope, than to determine exactly the point of contact between the limb of the ſun and the wire. On this account I eſteem the obſervations of the meridian altitude of the ſtars more accurate than thoſe of the ſun: And therefore fix upon the mean of all the *ſidereal obſervations* as the true

Latitude of Harvard-Hall at Cambridge, 42° 23′ 28″, 46

A REMARK.

The preceding obſervations will ſerve to determine the accuracy of the quadrant, as well as the latitude of the place. For this purpoſe I ſhall ſelect the obſervations which were made on β in the ſhoulder of *Aquarius*, and thoſe of the pole ſtar.

Apparent declination of β S.		6° 30′ 49,″3
Apparent declin. of the pole-ſtar N. 88° 8′ 41,″3		
Diſtance from the pole.	1 51 18, 7	91 51 18, 7
Below the pole at the time of obſerv.	1 51 18, 7	

True meridian altitude of β,	41° 5′ 42″
True meridian altitude of the pole-ſtar,	40 32 9
Sum of the declinations and altitudes,	179 59 59

Hence it appears, that the ſum of all the errors in the aſſumed declinations of theſe two ſtars, in the refraction, quadrant, and mean altitudes, do not amount to more than one ſecond. It may therefore be preſumed that the quadrant, obſervations, and elements of the calculations are very exact. The reaſon why the obſervations on β in *Aquarius* were choſen to examine the quadrant by, was becauſe they are nearer the mean latitude than thoſe of any other ſtar, and therefore may be preſumed to be the moſt correct.

II. Obſervations of the variation and dip of the magnetic needle, at the Univerſity in Cambridge.

Time.	Variation.	Dip.	Obſerver.
Year. Mon. D. H.	° ′	° ′	
1708,	9 0 W		Mr. Brattle,
1742,	8 0 W		Dr. Winthorp.
1757,	7 20 W		Dr. Winthorp.
1761, Feb. 25,	7 14 W		Mr. Williams.
1763,	7 0 W		Dr. Winthorp.
1780, Dec. 25, 1, P. M.	7 2 W	69 51	Mr. Williams.
1782, June 21, 4, P. M.	6 46 W	69 41	Mr. Williams.
1783, Dec. 23, 3, P. M.	6 52 W	69 41	Mr. Williams.

In the year 1782, Profeſſor Sewall obſerved the diurnal variation of the magnetic needle during ſeveral months. At the

the ſame time I obſerved the diurnal alterations in the dipping needle. Theſe obſervations are too numerous to be inſerted here. In general, there is a remarkable regularity in the obſervations taken by the variation needle. The variation generally increaſes from ſeven or eight o'clock, A. M. till about two or three, P. M. From this time it generally decreaſes until ſeven or eight the next morning. The inclination or dip is ſubject to rather greater diurnal alterations than the variation; but they do not ſeem to be ſo regular in their changes. The leaſt inclination I have ever obſerved was 68° 21′; the greateſt 70° 56′.

III. *A Table of the Equations to equal Altitudes, for the Latitude of the University of* Cambridge, 42°23′ 28″ N. *with an Account of it's Construction and Use. By the Reverend* JOSEPH WILLARD, *President of the University.*

THE regulation of a clock, which is made use of for astronomical purposes, is of the utmost importance. Unless it's going is accurately ascertained, the observations made by it, however excellent in other respects, can be of no use. Every thing, therefore, which tends to facilitate it's regulation, is worthy of attention.

The best method to ascertain the going of a clock, where a person has not a transit instrument fixed in the meridian, is by equal altitudes of the sun, taken by some instrument adapted to the purpose. Hadley's octant is the most easily obtained; and double altitudes may be taken by it, by reflection from a bowl of some liquid, which will not be easily put into motion by the air. The oil of tar, or very clean molasses will answer the purpose well.

The method is, to take the altitude of the sun's upper or lower limb, or both, in the morning as far from noon as may be convenient, and note the time by the clock to a second. The time must be noted in the afternoon, when the altitude is the same. Then, add half the interval between the two observations, to the time of the morning observation, which will give the time by the clock, nearly, when the sun's center passed the

the meridian. This would be the apparent noon exactly, if the ſun did not alter his declination: But as this is conſtantly varying, a ſmall equation, ariſing from the change of declination between the forenoon and afternoon obſervations, muſt be applied to the time of noon thus found, except at the ſolſtices, when the variation is too ſmall to make any equation neceſſary.

ILLUSTRATION.

In Plate I. Fig. VI. let EPQL be the hour circle of ſix o'clock, and ECQ a portion of the Equator. Let P be the north-pole, L the ſouth; and PZL the meridian of ſome place. Let the arc *lZt* mark the latitude of a given place: Then, the point Z will be it's zenith; and the arc HOR will be a portion of the horizon, O being 90° diſtant from Z. Let the arc *mxg* mark the ſun's declination, in the morning, at a time when his altitude is taken, and *avn* the declination in the afternoon, when his altitude is the ſame as in the morning obſervation. Let the angle ZP☉ be the diſtance of the ſun from the meridian, at the time of the morning obſervation = the half interval between the forenoon and afternoon obſervations, nearly; then ſide PZ will be the co-latitude of the place, the ſide P☉ the ſun's co-declination, and the ſide Z☉ the ſun's co-altitude or zenith diſtance. Let the co-altitude Z☉ be ſet off from Z to *r*, a point in the arc of the ſun's declination, at the time of the forenoon obſervation, and through *r* draw the arc P*r*L. Let Z☉ alſo be ſet off from Z to S, a point in the arc of the ſun's declination, at the time of the afternoon obſervation, and through S draw the arc PSL. Then, it will be evi-

dent,

dent, that when the ſun has the ſame zenith diſtance in the afternoon obſervation that he had in the forenoon, he will be further diſtant from the meridian by the ſpace *pq*, meaſured upon the Equator, equal to the angle *p*P*q*. Biſect the angle ☉PS, and draw the pricked arc P*b*L, (the ſame as adding the half interval to the time of the forenoon obſervation) which ſhews the mean noon; but it is as much after the apparent noon, or the true time of the ſun's paſſing the meridian, as the ſpace C*b* upon the Equator, which is equal to half *pq*. The time anſwering to C*b*, therefore, muſt, in this caſe, be ſubtracted from the mean noon, which will reduce it to the meridian PCL, or, which is the ſame thing, give the true time when the ſun paſſed the meridian, by the clock. This equation, C*b*, may eaſily be found trigonometrically, by the triangles P☉Z and PSZ.

EXAMPLE.

At Cambridge, latitude 42° 23′ 28″ N. ſuppoſe the altitude of the ſun taken April 2, 1783, at 8h. 40′, A. M. i. e. at 3h. 20′, or 50°, from the meridian, and the correſponding altitude taken in the afternoon; required the equation to the correſponding altitudes?

April 2, 1783, at 8h. 40′, A.M. ☉'s declination,	5° 1′ 00″	Com. = P☉ 84° 59′ 0″
At 3h. 20′, P. M. ditto,	5 7 22	Com. = PS 84 52 38
Co-latitude,		= PZ 47 36 32
Angle ZP☉ = 3h. 20′		= 50 0 0

In the triangle ZP⊙, given sides PZ and P⊙, and the included angle ZP⊙, to find side Z⊙ the co-altitude or zenith distance of the sun at the time of observation? Zi is perpendicular to P⊙.

Radius,		
: Sine co-angle ZP⊙	40° 0′ 0″	9 8080675
:: Tangent PZ	47 36 32	10 0396048
: Tangent segment Pi	35 9 6	9 8476723
P⊙	84 59 0	
Diff. = segment ⊙i	49 49 54	
Sine Co-Pi	54 50 54	9 9125573
: Sine Co-⊙i	40 10 6	9 8095836
:: Sine Co-PZ	42 23 28	9 8287809
: Sine Co-Z⊙	32 7 55	9 7258072
Z⊙ = ZS	57 52 5	

In the triangle ZPS are given the three sides to find angle ZPS.

PZ	47 36 32
PS	84 52 38
ZS = Z⊙	57 52 5
Sum of sides	190 21 15
½ sum	95 10 37, 5
½ sum—PZ	47 34 5, 5
½ sum—PS	10 17 59, 5

K PZ

PZ	Sine 47° 36′ 42″	9	8683857
x PS	Sine 84 52 38	9	9982618
		19	8666475
: Radius square,		20	
:: ½ sum of sides—PZ = Sine	47 34 5, 5	9	8681039
x ½ sum of sides—PS = Sine	10 17 59, 5	9	2523671
: Sine of square of ½ ∠ ZPS	2	19	2538235
Sine of ½ ∠ ZPS	25 3 33, 7	9	6769117
	x 2		
Angle ZPS	50 7 7, 4		
Subtract ZP☉	50		
Remains space *pq*, or angle *pPq*	7 7, 4		
	x 4		
Reduced to time,	28″ 29‴, 6		
The ½ of which is C*b* = the equation to the equal altitudes,	14 14, 8		

This method is accurate, but tedious; and to ſhorten the work, formulas have been invented. One deduced by Mr. William Wales from art. 256 of Simpſon's Fluxions is, perhaps, as eaſy and conciſe as any. It is divided into two parts. The firſt is compoſed of the change in the ſun's declination, during half the interval between the obſervations, multiplied by the co-ſecant of the ſun's horary angle at the times of the obſerva-

vations,

tions, multiplied again by the tangent of the geographical latitude. The ſecond part conſiſts of the ſaid change in the declination, multiplied by the tangent of the ſun's declination, multiplied again by the co-tangent of the ſun's horary angle. When the ſun's declination is north, this ſecond part of the equation is to be ſubtracted from the firſt; but when it is ſouth, it is to be added to it; and the difference or ſum will be the equation to the equal altitudes: Which equation is additive, when the ſun is declining ſouthward; i. e. when the declination is north decreaſing or ſouth increaſing; but when the contrary, it is ſubtractive.

Theſe rules are to be obſerved, when the latitude is north: They muſt be inverted, when it is ſouth.

The exactneſs of this formula will appear, by making uſe of the foregoing example.

Whole change in declination 6′ 22″. Half do. 3′ 11″ added to 5° 1′ 0″, the declination at the time of the morning obſervation, gives 5° 4′ 11″ for ☉'s declination at noon.

Half change of declin.	3′ 11″=191″	2 2810334
x Secant of co-hour angle,	40° 0′ 0	10 1157460
x Tangent of the latitude,	42 23 28	9 9603952
Firſt part of the equation,	227, 6	2 3571746

Half change declination	191″	2.2810334
x Tangent declination,	5° 4′ 11	8.9479970
x Tangent co-hour angle,	40 0 0	9.9238135
Second part of the equation,	14, 2	1.1528439
Which subtracted from the first part,	227, 6	
Leaves the equat. to the equal altitudes,	213, 4	
	= 3 33, 4	
	x 4	
The equation in time,	14″ 13‴, 6	

By this formula was the following table calculated; but it is to be observed, that the sun's longitude, instead of the declination answering to it, is put down for the argument, as being the most convenient.

A

A TABLE of the EQUATIONS to equal Altitudes. For Lat. 42° 23′ 28″ N.

☉'s longitude.	Half Interval between the Observations.															
	H. M. II 0	H. M. II 10	H. M. II 20	H. M. II 30	H. M. II 40	H. M. II 50	H. M. III 0	H. M. III 10	H. M. III 20	H. M. III 30	H. M. III 40	H. M. III 50	H. M. IV 0	H. M. IV 10	H. M. IV 20	H. M. IV 30
S. D.	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴
0 — 0	14.25	14.33	14.41	14.49	14.58	15. 7	15.16	15.27	15.40	15.54	16. 7	16.22	16.38	16.55	17.13	17.33
5	13.52	14. 0	14. 9	14.18	14.27	14.37	14.47	14.59	15.12	15.26	15.40	15.56	16.13	16.31	16.51	17.12
10	13.13	13.22	13.31	13.40	13.50	14. 0	14.11	14.24	14.39	14.54	15. 9	15.25	15.43	16. 2	16.23	16.44
15	12.31	12.41	12.51	13. 1	13.11	13.21	13.32	13.46	14. 1	14.17	14.32	14.49	15. 7	15.26	15.47	16.10
20	11.45	11.55	12. 5	12.15	12.26	12.37	12.49	13. 3	13.18	13.33	13.50	14. 7	14.26	14.46	15. 8	15.30
25	10.56	11. 6	11.16	11.27	11.38	11.49	12. 2	12.16	12.31	12.46	13. 3	13.21	13.40	14. 0	14.23	14.46
I — 0	10. 6	10.16	10.26	10.36	10.47	10.59	11.12	11.25	11.40	11.55	12.12	12.30	12.50	13.11	13.33	14.56
5	9. 4	9.23	9.34	9.44	9.55	10. 7	10.19	10.32	10.48	11. 3	11.20	11.38	11.58	12.19	12.40	13. 2
10	8.21	8.30	8.40	8.50	9. 1	9.12	9.25	9.39	9.54	10. 8	10.25	10.42	11. 1	11.21	11.41	12. 4
15	7.27	7.36	7.46	7.55	8. 6	8.17	8.29	8.42	8.56	9.10	9.26	9.44	10. 3	10.22	10.42	11. 3
20	6.35	6.43	6.52	7. 1	7.11	7.21	7.33	7.45	7.59	8.13	8.28	8.44	9. 2	9.20	9.39	9.58
25	5.43	5.50	5.58	6. 7	6.16	6.26	6.37	6.49	7. 1	7.13	7.27	7.41	7.57	8.14	8.32	8.52
II — 0	4.52	4.58	5. 5	5.12	5.20	5.29	5.39	5.50	6. 2	6.13	6.25	6.38	6.52	7. [illegible]	7.23	7.40
5	4. 0	4. 6	4.13	4.20	4.27	4.35	4.43	4.52	5. 2	5.11	5.21	5.32	5.44	5.57	6.11	6.2[illegible]
10	3.10	3.15	3.21	3.27	3.33	3.39	3.46	3.53	4. 0	4. 7	4.16	4.26	4.36	4.47	4.49	5.12
15	2.22	2.25	2.29	2.33	2.38	2.43	2.48	2.53	2.59	3. 5	3.12	3.19	3.27	3.36	3.46	3.55
20	1.33	1.35	1.38	1.41	1.44	1.48	1.52	1.56	2. 0	2. 3	2. 7	2.12	2.18	2.24	2.30	2.37
25	0.45	0.46	0.47	0.49	0.51	0.53	0.55	0.57	0.59	1. 1	1. 3	1. 5	1. 8	1.11	1.15	1.19
III + 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0
5	0.45	0.46	0.47	0.49	0.51	0.53	0.55	0.57	0.59	1. 1	1. 3	1. 5	1. 8	1.11	1.15	1.19
10	1.33	1.35	1.38	1.41	1.44	1.48	1.52	1.56	2. 0	2. 3	2. 7	2.12	2.18	2.24	2.30	2.37
15	2.22	2.25	2.29	2.33	2.37	2.42	2.47	2.52	2.59	3. 5	3.12	3.19	3.27	3.36	3.45	3.55
20	3. 9	3.14	3.19	3.24	3.30	3.37	3.44	3.51	3.59	4. 6	4.15	4.26	4.36	4.47	4.49	5.11
25	3.5[illegible]	4. 4	4.11	4.18	4.25	4.33	4.41	4.49	4.58	5. 7	5.18	5.30	5.42	5.55	6. 9	6.24
IV + 0	4.50	4.57	5. 4	5.11	5.19	5.28	5.38	5.48	5.59	6.10	6.22	6.36	6.50	7. 6	7.20	7.36
5	5.43	5.50	5.58	6. 6	6.15	6.24	6.35	6.46	6.59	7.11	7.25	7.40	7.56	8.13	8.31	8.49
10	6.34	6.42	6.50	6.59	7. 9	7.20	7.31	7.43	7.56	8. 9	8.24	8.40	8.58	9.16	9.35	9.56
15	7.26	7.34	7.43	7.52	8. 2	8.13	8.25	8.38	8.52	9. 6	9.22	9.39	9.57	10.16	10.37	10.59
20	8.19	8.27	8.36	8.46	8.57	9. 9	9.22	9.36	9.50	10. 4	10.21	10.38	10.56	11.16	11.38	11.59
25	9. 9	9.18	9.28	9.39	9.50	10. 1	10.13	10.27	10.42	10.57	11.14	11.31	11.50	12.11	12.33	12.56
V + 0	10. 1	10.10	10.20	10.30	10.41	10.53	11. 6	11.20	11.35	11.49	12. 6	12.24	12.43	13. 3	13.25	13.48
5	10.51	11. 0	11. 9	11.19	11.30	11.42	11.55	12. 9	12.24	12.39	13.56	13.14	13.33	13.53	14.15	14.38
10	11.39	11.48	11.57	12. 7	12.18	12.29	12.41	12.55	13.10	13.24	12.56	13.59	14.18	14.38	15. 0	15.22
15	12.24	12.33	12.42	12.52	13. 3	13.14	13.25	13.38	13.52	14. 8	14.23	14.40	14.58	15.17	15.38	15.59
20	13. 8	13.15	13.23	13.32	13.41	13.53	14. 4	14.16	14.30	14.45	14.59	15.15	15.32	15.54	16.12	16.33
25	13.43	13.51	14. 0	14.10	14.20	14.30	14.40	14.51	15. 4	15.18	15.31	15.46	16. [illegible]	16.[illegible]	16.4[illegible]	17. 1
VI + 0	14.17	14.24	14.32	14.40	14.49	14.59	15. 8	15.19	15.31	15.44	15.57	16.12	16.28	16.45	17. 3	17.2[illegible]

A TABLE of the EQUATIONS to equal Altitudes. For Lat. 42° 23′ 28″ N.

Half Interval between the Obſervations.

⊙'s longitude.	H. M. II 0	H. M. II 10	H. M. II 20	H. M. II 30	H. M. II 40	H. M. II 50	H. M. III 0	H. M. III 10	H. M. III 20	H. M. III 30	H. M. III 40	H. M. III 50	H. M. IV 0	H. M. IV 10	H. M. IV 20	H. M. IV 30
S. D.	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴	″ ‴
VI + 0	14.17	14.24	14.32	14.40	14.49	14.59	15. 8	15.19	15.31	15.44	15.57	16.12	16.28	16.45	17. 3	17.22
5	14.44	14.51	14.58	15. 6	15.15	15.24	15.33	15.43	15.54	16. 6	16.18	16.32	16.47	17. 3	17.20	17.3[illegible]
10	15. 6	15.12	15.18	15.25	15.33	15.42	15.50	16. 0	16.10	16.21	16.32	16.45	16.59	17.13	17.28	17.4[illegible]
15	15.21	15.27	15.33	15.39	15.45	15.52	15.59	16. 8	16.18	16.29	16.39	16.51	17. 4	17.17	17.31	
20	15.29	15.33	15.38	15.44	15.50	15.56	16. 2	16.11	16.20	16.30	16.39	16.49	17. 0	17.12	17.25	
25	15.28	15.32	15.37	15.42	15.47	15.53	15.59	16. 5	16.12	16.20	16.28	16.37	16.47	16.57		
VII + 0	15.17	15.21	15.25	15.29	15.36	15.39	15.43	15.49	15.56	16. 3	16.10	16.18	16.26	16.36		
5	14.58	15 0	15. 3	15. 6	15.10	15.15	15.19	15.24	15.30	15.36	15.41	15.48	15.56			
10	14.30	14.32	14.34	14.36	14.39	14.42	14.45	14.50	14.55	15. 0	15. 4	15.10	15.16			
15	13.46	13.47	13.48	13.50	13.52	13.55	13.58	14. 2	14. 7	14.12	14.16	14.21				
20	12.52	12.53	12.55	12.57	12.59	13. 2	13. 4	13. 7	13.10	13.13	13.15					
25	11.47	11.48	11.49	11.50	11.51	11.53	11.56	11.59	12. 2	12. 5						
VIII + 0	10.31	10.31	10.32	10.33	10.34	10.36	10.38	10.40	10.43							
5	9. 4	9. 4	9. 5	9. 6	9. 7	9. 8	9. 9	9.10	9.12							
10	7.29	7.29	7.30	7.30	7.31	7.31	7.32	7.32	7.33							
15	5.45	5.45	5.45	5.46	5.46	5.46	5.46	5.47	5.47							
20	3.51	3.51	3.51	3.52	3.52	3.52	3.52	3.53	3.53							
25	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	2. 0							
IX — 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0	0. 0							
5	1.59	1.59	1.59	1.59	1.59	1.59	1.59	1.59	2. 0							
10	3.51	3.51	3.51	3.52	3.52	3.52	3.52	3.53	3.53							
15	5.45	5.45	5.45	5.46	5.46	5.46	5.46	5.47	5.47							
20	7.30	7.30	7.31	7.31	7.32	7.32	7.33	7.33	7.34							
25	9. 6	9. 6	9. 7	9. 8	9. 9	9.10	9.11	9.12	9.14							
X — 0	10.33	10.35	10.35	10.36	10.37	10.39	10.41	10.43	10.45							
5	11.51	11.52	11.53	11.54	11.56	11.58	12. 0	12. 3	12. 6	12. 9						
10	12.58	12.59	13. 0	13. 1	13. 2	13. 4	13. 5	13. 8	13.12	13.17	13.21					
15	13.53	13.54	13.55	13.56	13.58	14. 0	14. 2	14. 6	14.11	14.16	14.20	14.26				
20	14.34	14.36	14.38	14.41	14.45	14.49	14.52	14.56	15. 0	15. 5	15. 9	15.15	15.22			
25	15. 5	15. 7	15.10	15.13	15.17	15.22	15.26	15.31	15.37	15.43	15.49	15.56	16. 4			
XI — 0	15.25	15.29	15.33	15.37	15.42	15.48	15.53	15.59	16. 6	16.13	16.19	16.27	16.36	16.45		
5	15.35	15.39	15.44	15.49	15.55	16. 1	16. 7	16.15	16.23	16.31	16.35	16.46	16.48	17. 8		
10	15.36	15.41	15.46	15.52	15.59	16. 6	16.13	16.52	16.31	16.41	16.46	16.58	17. 1	17.22	17.34	
15	15.29	15.35	15.41	15.47	15.54	16. 2	16.10	16.19	16.29	16.39	16.49	17. 1	17.14	17.27	17.41	17.5[illegible]
20	15.14	15.21	15.28	15.36	15.46	15.52	16. 0	16. 9	16.19	16.30	16.41	16.54	17. 8	17.23	17.39	17.3[illegible]
25	14.53	15. 0	15. 8	15.16	15.25	15.34	15.42	15.52	16. 3	16.15	16.27	16.41	16.56	17.12	17.29	
0 — 0	14.25	14.33	14.41	14.49	14.58	15. 7	15.16	15.27	15.40	15.54	16. 7	16.22	16.38	16.55	17.13	17.3[illegible]

The uſe of the foregoing table will appear eaſy by an example.

April 12, 1782, the following correſponding double altitudes of the ſun were taken at Cambridge with Hadley's octant.

	D. Alt.	Foren. Obſ.	Afternoon.	Interval.	½ Interval.	Mean Noon.
Sun's upper limb.	54°00′	7h 56′ 27″	4h 11′ 0″	8h 14′ 33″	4h 7′ 16½″	12h 3′ 43″ 30‴
	58 00	8 7 33	3 59 50	7 52 17	3 56 8½	12 3 41 30
Sun's lower limb.	59 20	8 14 18	3 53 0	7 38 42	3 49 21	12 3 39 00
	61 20	8 20 3	3 47 22	7 27 19	3 43 39	12 3 42 30

Mean noon by the clock by the above obſervations,	12 3 41 37
Equation by the table for change of declina. during the ½ interval,	—13 49
Apparent time by clock when ☉'s center paſſed the meridian,	12 3 27 48

Hence, we find that the clock was 3′ 27″ 48‴ too faſt for apparent time.

The mean ½ interval to theſe correſponding altitudes is 3h. 54′ 6″. The ſun's longitude at noon, on the above day, was, at Paris, by *Connoiſance des Temps*, 0S. 22° 40′; therefore, allowing for the difference of meridians, it was at Cambridge, 0S. 22° 52′. Hence, by taking the proportion in the table between the equations for the ½ interval 3h. 50′ and 4h. 0′, and for the longitudes 0S. 20° and 0S. 25°, for the ½ interval 3h. 54′ 6″ and the longitude 0S. 22° 52′, we ſhall find 13″ 49‴, as in this example.

The

The table of equations to equal altitudes is calculated for latitude 42° 23′ 28″; but by adding or ſubtracting the following ſmall equations, or proportional parts of them, the general equations may be found, as far as two degrees in latitude more or two degrees leſs. Theſe ſmall equations are put down with their ſign for the ſun's longitudes, the half intervals and the latitudes to which they are calculated; and they need no explanation.

		½ Intervals. 2h.	½ Intervals. 4h. 30′		½ Intervals. 2h.	½ Intervals. 4h. 30′
	° ′ ″	‴	‴	° ′ ″	‴	″ ‴
S. 0 S. 0 S. 0 ☉'s long. 0 0 & VI. 0	Lat. 41 23 28 N	Equ. — 30	— 36.	Lat. 40 23 28	Equ. — 59	— 1 11
	Lat. 43 23 28	+ 31	+ 37.	Lat. 44 23 28	+ 1 2	+ 1 17
☉'s long. I. 15 IV. 15 VII. 15 & X. 15	Lat. 41 23 28	— 21	— 26.	Lat. 40 23 28	— 42	— 51
	Lat. 43 23 28	+ 22	+ 27.	Lat. 44 23 28	+ 45	+ 52

IV. *Astronomical Observations, made in the State of* Massachusetts. *By Professor* WILLIAMS.

Observations of the eclipses of the sun and moon, in the years 1761, and 1764; and from 1770 to 1784.

1. An observation of a lunar eclipse, November 12, 1761, at *Waltham.*

THE weather was so cloudy that I could only make the following observations of this eclipse.—

	Temp. app.
The shadow reached *Kepler,*	16h. 59′ 0″
Mare Vaporum,	17 7 40
Tycho,	14 25
Menelaus,	17 28
Mare Crisium,	28 11
Total immersion,	45 10

2. An observation of a lunar eclipse, March 17, 1764, at *Waltham.*

The moon rose behind a cloud that lay along the horizon, but soon began to appear: About 6h. 10′ I saw her considerably eclipsed: *Tycho* was then covered.

The shadow reached *Nectaris,*	6h. 30′
Copernicus,	32
Mare Vaporum,	43
Menelaus,	55

The ſhadow reached	*Archimedes,*		56′
	Mare Criſium,	7$^{h.}$	3
covers	*Mare Criſium,*		17
	Tycho begins to appear,	8	12
leaves	*Mare Criſium,*		21
End of the eclipſe,			39 54″

Theſe obſervations were made with a reflecting teleſcope about four feet in length: And the clock was adjuſted by a meridian line, and correſponding altitudes of the ſun.

3. An obſervation of a ſolar eclipſe, November 6, 1771, at *Bradford.*

The beginning of this eclipſe could not be obſerved, the weather being cloudy. At 1$^{h.}$ 36′ 42″, it was evident that the eclipſe was begun. The clouds prevented alſo any obſervation of the quantity of the eclipſe: But I had a good obſervation of the end, which was at 3$^{h.}$ 47′ 2″ apparent time.

4. An obſervation of a lunar eclipſe, April 6, 1773, at *Bradford.*

			Temp. app.
Beginning of the eclipſe,			14$^{h.}$ 32′ 38″
The ſhadow reaches	*Grimaldus,*		40 43
	Mare Humorum,		41 53
covers	*Mare Humorum,*		47 38
reaches	*Tycho,*		52 23
	Kepler,	15	1 28
	Copernicus,		11 20
	Mare Tranquillitatis,		27 13
	Mare Fæcunditatis,		32 54

Mare

The ſhadow reaches	*Mare Serenitatis,*	42′ 15″
	Mare Criſium,	58 8
leaves	*Mare Criſium,*	16h. 43 23
	Mare Humorum,	45 23
	Mare Tranquillitatis,	52 25
	Tycho,	59 38
End of the eclipſe,		17 20 10

The laſt obſervation was attended with ſome uncertainty ;—the moon being near the horizon, and the day-light far advanced.

5. An obſervation of a lunar eclipſe, July 30, 1776, at *Bradford.*

This eclipſe was total : But the beginning of it, and the beginning of total darkneſs were inviſible at *Bradford*, both happening before the moon roſe. I was in hopes to have ſeen the end of total darkneſs, but was prevented by clouds. At 8h. 30′ the ſky became perfectly clear, ſo that I had a good obſervation of the end of the eclipſe, which was at 9h. 2′ 44″.

6. An obſervation of a ſolar eclipſe, June 24, 1778, at *Bradford.*

The beginning of this eclipſe could not be obſerved, the ſun being wholly covered with clouds. At 10h. 8′ they broke away : And though often interrupted afterwards, I was able to note the following phenomena.

About 10h. 16′, the horns of the ſun were obſerved to have an equal altitude, being in a line parallel to the horizon. At 10h. 23′ the lucid parts of the ſun amounted to 2′ 45″; whence,

as the ſun's apparent diameter was 31′ 34″, the eclipſed parts were 28′ 49″, or 10 digits and 57 minutes. This was very near the time of the greateſt obſcuration: But whether it was exactly ſo I could not determine, the ſun being obſcured juſt before and after this obſervation. At $10^{h.}$ 25′ a large ſpot emerged from the ſhadow. At $10^{h.}$ 59′ four other large ſpots were wholly within the lucid part. At the end of the eclipſe the ſky was become clear, and by a good obſervation I found this to be at $11^{h.}$ 38′ 16″ apparent time.

During the eclipſe, there was a very ſenſible alteration in the ſtate of the *air*. A chill, and a damp were very generally felt. The mercury in the thermometer at $9^{h.}$ 4′, juſt before the eclipſe began, was at $67°\frac{1}{2}$. At $10^{h.}$ 20′, it fell to 66°. At the end of the eclipſe it roſe to 73°; and at noon it was at $74°\frac{1}{2}$.

As the time of the greateſt obſcuration came on, that part of the ſky which was free from clouds, changed from an azure blue, to a more dark and duſky colour: And the dew fell ſo faſt as to wet the paper we were uſing to a conſiderable degree.

As this eclipſe was *total* in ſome of the *ſouthern ſtates*, I was very deſirous to have it carefully obſerved in ſeveral places, in hope that a ſufficient number of obſervations might be collected to determine the exact path and limits of the ſhadow: And it was with much regret that I found myſelf prevented by the weather from making a more compleat obſervation.

7. An obſervation of a lunar eclipſe, December 3, 1778, at *Bradford*.

Beginning

	Temp. app.		
Beginning of the eclipſe,	11$^{h.}$	41′	14″
The ſhadow reaches *Mare Serenitatis*,	12	6	6
Copernicus,		13	53
Mare Tranquillitatis,		23	12
Mare Criſium,		28	15
leaves *Mare Imbrium*,	13	47	0
Mare Serenitatis,		54	0
Mare Criſium,		59	30
End of the eclipſe,	14	5	20

Theſe obſervations were made in a very favourable ſtate of the air.

8. An obſervation of a lunar eclipſe, and an emerſion of Jupiter's ſecond ſatellite, May 29, 1779, at *Bradford*.

The emerſion of the ſatellite was at	8	58	13
Beginning of the eclipſe,	10	15	41
The ſhadow touches *Tycho*,		35	15
Copernicus,		40	35
Mare Serenitatis,	11	0	6
Mare Criſium,		18	15
Beginning of total darkneſs,		28	39
End of total darkneſs,	12	50	41
The ſhadow leaves *Tycho*,	13	27	7
Mare Serenitatis,		38	57
Mare Criſium,		54	49
End of the eclipſe,	14	3	51

During

During the whole time of this eclipſe, the weather was very favourable for obſervation. All the obſervations made at *Bradford*, were taken with a reflector made by *Nairne*, magnifying about 55 times. The times were ſhewn by a good clock, carefully adjuſted by equal altitudes of the ſun, the day before and the day after the eclipſe.

9. Obſervations of a ſolar eclipſe, October 27, 1780, made on the eaſt ſide of *Long-Iſland*, in *Penobſcot-Bay*.

A total eclipſe of the ſun is a curious and uncommon phenomenon. From the principles of aſtronomy it is certain that a central eclipſe will happen, in ſome part of the earth, in the courſe of every year: But it is but ſeldom that a total eclipſe of the ſun is ſeen in any particular place. A favourable opportunity preſenting for viewing one of theſe eclipſes on October 27, 1780, the American Academy of Arts and Sciences, and the Univerſity at Cambridge, were deſirous to have it properly obſerved in the eaſtern parts of the State, where, by calculation, it was expected it would be total. With this view they ſolicited the government of the Commonwealth, that a veſſel might be prepared to convey proper obſervers to *Penobſcot-Bay*; and that application might be made to the officer who commanded the *Britiſh* garriſon there, for leave to take a ſituation convenient for this purpoſe.

Though involved in all the calamities and diſtreſſes of a ſevere war, the government diſcovered all the attention and readineſs to promote the cauſe of ſcience, which could have been expected in the moſt peaceable and proſperous times; and paſſed a reſolve, directing the Board of War to fit out the

Lincoln

Lincoln galley to convey me to *Penobſcot*, or any other port at the eaſtward, with ſuch aſſiſtants as I ſhould judge neceſſary.

Accordingly, I embarked October 9, with Mr. Stephen Sewall, Profeſſor of the Oriental Languages, James Winthrop, Eſq; Librarian, Forteſque Vernon, A. B. and Meſſ'rs. Atkins, Davis, Hall, Dawſon, Renſalear, and King, Students in the Univerſity. We took with us an excellent clock, an aſtronomical quadrant of $2\frac{1}{2}$ feet radius, made by *Siſſons*, ſeveral teleſcopes, and ſuch other apparatus as were neceſſary.

On the 17th we arrived in *Penobſcot-Bay*. The veſſel was directed to come to anchor in a cove on the eaſt ſide of *Long-Iſland*. After ſeveral attempts to find a better ſituation for obſervations, we fixed on this place as the moſt convenient we had reaſon to expect :* And on the 19th we put our inſtruments on ſhore, ſet up the clock and quadrant in a building facing towards the ſouth, near the houſe of Mr. *Shubael Williams*, where the following obſervations were made.

OCTOBER 20.

Correſponding altitudes of the ſun taken with a reflector fitted with vertical and horizontal wires.

Time

* As the officer who commanded at *Penobſcot*, in his anſwer to the application of the government, had limitted us to a time wholly inadequate to our purpoſe, from the 25th to the 30th of October, we were obliged to make a ſecond application for leave to enter *Penobſcot-Bay* Leave was granted, but with a poſitive order to have no communication with any of the inhabitants, and to depart on the 28th, the day after the eclipſe. Being thus retarded and embarraſſed by military orders, and allowed no time after the eclipſe to make any obſervations, it became neceſſary to ſet up our apparatus and begin our obſervations without any further loſs of time. In the courſe of which, we received every kind of aſſiſtance from Capt. *Henry Mowatt*, of the Albany, which it was in his power to give.

Time by the clock.

Eastern az.			Western az.			Meridian.		
8h.	15′	44″	3h.	54′	43″	12h.	5′	13″,5
	21	58		48	28			13
	28	48		41	34			11
	31	30		38	57			13, 5
Mean,						12	5	12, 75
Equation of altitudes,						+		17, 50
☉'s center on the meridian,						12	5	30, 25
Clock too fast,							5	30, 25

Meridian altitude of the sun's upper limb, taken with the astronomical quadrant, 35° 15′ 45″

OCTOBER 21.

Corresponding altitudes of the sun taken with a reflector.

Time by the clock.

Eastern az.			Western az.			Meridian.		
8h.	15′	11″	3h.	58′	20″	12h.	6′	45″,5
	18	45		54	46			45, 5
	21	35		51	52			43, 5
	28	28		45	5			46, 5
	32	7		41	23			45
	35	17		38	12			44, 5
	45	53		27	36			44, 5
Mean,						12	6	45
Equation of altitudes,						+		17, 5
☉'s center on the meridian,						12	7	2, 5
Clock gains in 24 hours,							1	32, 25

OCTOBER

OCTOBER 22.

Thick fog all day. No aſtronomical obſervations. At 8^h. 15′, A. M. I put the clock back 15′, and lengthened the pendulum.

OCTOBER 23.

Thick fog all day. No aſtronomical obſervations.

OCTOBER 24.

Correſponding altitudes of the ſun, taken with the quadrant.

Time by the clock.

Eaſtern az.			Weſtern az.			Meridian.		
8^h.	1′	47″	3^h.	44′	58″	11^h.	53′	22″,5
	4	55		41	52			23, 5
	7	58		38	54			26
	11	31		35	23			27
	14	57		31	51			24

Mean,	11	53	24, 60
Equation of altitudes,	+		16, 75
☉'s center on the meridian,	11	53	41, 35
Clock too ſlow,		6	58, 65

Meridian altitude of the ſun's upper limb,	33°51′43″
In the night I obſerved the meridian altitude of	
Rigel,	37 16 15
Sirius,	29 19 0
Procyon,	51 30 26

OCTOBER 25.

Correſponding altitudes of the ſun, taken with the quadrant.

Time by the clock.

Eastern az.			Western az.			Meridian.		
8h.	31′	17″	3h.	17′	19″	11h.	54′	18″
	35	4		13	31			17, 5
	36	43		11	53			18
	38	16		10	20			18
	42	4		6	28			16
	45	16		3	16			16
	46	0		2	33			16, 5
	47	38		0	53			15, 5
	49	16	2	59	11			13, 5
	57	16		51	8			12
	59	3		49	25			14
9	0	39		47	47			13

Mean,	11	54	15, 66
Equation of altitudes,	+		16, 63
☉'s center on the meridian,	11	54	32, 29
Clock too slow,		5	27, 71
Clock gains in 24 hours,			50, 94

Meridian altitude of the sun's upper limb,	33° 31′ 4″
In the night I observed the meridian altitude of	
Rigel,	37 16 15
Sirius,	29 19 6
Procyon,	51 30 30

OCTOBER 26.

Corresponding altitudes of the sun, taken with the quadrant.

Time

Time by the clock.

Eastern az.			Western az.			Meridian.		
8h.	30′	56″	3h.	19′	13″	11h.	55′	4″,5
	32	31		17	41			6
	34	3		16	5			4
	34	45		15	26			5, 5
	36	25		13	46			5, 5
	37	56		12	13			4, 5

Mean,	11	55	5
Equation of altitudes,	+		16, 53
☉'s center on the meridian,	11	55	21, 53
Clock too ſlow,		4	38, 47
Clock gains in 24 hours,			49, 24

OCTOBER 27.

Correſponding altitudes of the ſun, taken with the quadrant.

Time by the clock.

Eastern az.			Western az.			Meridian.		
8h.	7′	18″	3h.	44′	30″	11h.	55′	54″
	8	32		43	15			53, 5
	9	14		42	32			53
	10	48		40	56			52
	12	6		39	40			53
	15	41		36	15			58
	17	23		34	26			54, 5
	18	33		33	13			53
	19	23		32	25			54
	20	56		30	48			52
	24	11		27	36			53, 5

Eastern az.	Western az.	Meridian.
25′ 25″	26′ 18″	51″,5
26 21	25 33	57
29 39	22 16	57, 5
31 12	20 36	54
33 21	18 28	54, 5
35 5	16 48	56, 5
36 27	15 26	56, 5

Mean,	11h.	55′	54, 33
Equation of altitudes,	+		16, 40
☉'s center on the meridian,	11	56	10, 73
Clock too slow,		3	49, 27
Clock gains in 24 hours,			49, 20

Observations of the Eclipse.

Four persons observed the solar eclipse with me. Professor Sewall, James Winthorp, Esq; Mess'rs. Dudley Atkins, and John Davis, two young gentlemen of the University, who had made good proficiency in mathematical studies, and been pretty constantly employed in making observations for several days before.

At 8h. 20′, A. M. with an object-glass micrometer applied to a reflecting telescope of twelve inches focus, made by *Short*, I measured the sun's diameter parallel to the horizon, and by a mean of ten observations, I found it 32′ 17″, 33.

With a reflecting telescope of two feet focal length, made by *Short*, and a magnifying power of ninety times, I observed the beginning of the eclipse at 11h. 11′ 8″.

Soon

Soon after I had noted the beginning, I adjuſted the micrometer to the direction of the ſhadow; and during the increaſe of the eclipſe, made the following obſervations on the quantity.

App. time.			Lucid Parts by the Micrometer.			Lucid Parts reduced.		App. time.			Lucid Parts by the Micrometer.			Lucid Parts reduced.	
			Rev.	Parts.	Divis.						Rev.	Parts.	Divis.		
h.	′	″				′	″	h.	′	″				′	″
11	27	58	1	11	16	25	12, 8	12	0	48		17	19	12	17, 9
	29	1		10	16	24	31, 8		4	0		16	10 d	11	18, 3
	30	12		9	12	23	42, 5		6	52		13	7	9	8, 8
	33	38		8	7	22	51, 0		9	3		12	2	8	17, 4
	35	49		7	18	22	32, 6		12	48		10	15	7	21, 9
	38	14		5	12	20	57, 9		13	38		9	16	6	42, 8
	42	24		3	4	19	19, 3		17	26		7	2	4	51, 9
	45	24		1	6	18	1, 2		19	36		6	17 d	4	41, 5
	49	36	0	23	15	16	16, 3		21	24		5	14 d	3	54, 3
	51	53		22	7	15	18, 8		22	51		4	18	3	21, 4
	54	33		21	18	15	0, 3		25	13		2	10	1	42, 7
	56	16		19	13	13	27, 8		26	50		1	13	1	7, 8
	58	35		18	7	12	34, 4		28	48			12		24, 7

Immediately after the laſt obſervation, the ſun's limb became ſo ſmall as to appear like a circular thread, or rather like a very fine horn. Both the ends loſt their acuteneſs, and ſeemed to break off in the form of ſmall drops or ſtars; ſome of which were round, and others of an oblong figure. They would ſeparate to a ſmall diſtance: Some would appear to run together again, and others diminiſh until they wholly diſappeared. Finding it very difficult to meaſure the lucid part any longer, I obſerved again in the larger teleſcope, looking out for the total immerſion. After viewing the ſun's limb about a minute, I found almoſt the whole of it thus broken or ſeparated in drops, a ſmall part only in the middle remaining connected. Plate I. Fig. VII. This appearance remained about a minute, when one of my aſſiſtants, who was looking at the ſun with his naked eye, obſerved

ſerved that the light was increaſing. At this time I could not ſee any appearance of an increaſe of the lucid part. At 12$^{h.}$ 31′ 18″, it was evident that the broken parts of the ſun's limb began to increaſe and unite. I immediately applied to the micrometer and meaſured the chord of the lucid part, and found it amounted to 42° or 43° : This was from the extremity of each limb taken from the moſt diſtant parts that were viſible. I then meaſured the connected part of the limb, and found it to be 24° or 25°. As the light and limb were by this time very ſenſibly increaſing, I again began to meaſure the quantity of the lucid part, and made the following obſervations with the micrometer.*

App. time.			Lucid Parts by the Micrometer.			Lucid Parts reduced.		App. time.			Lucid Parts by the Micrometer.			Lucid Parts reduced.	
			Rev.	Parts.	Diviſ.						Rev.	Parts.	Diviſ.		
h.	′	″				′	″	h.	′	″				′	″
12	33	36	0,	1	11	1	3, 7		6	10		21	1	14	25, 3
	35	48		3	1	2	5, 3		12	29	1	0	0	17	7, 8
	38	13		4	8	3	0, 8		14	5		1	7	18	8, 3
	40	18		5	13	3	52, 2		17	53		3	5	19	21, 4
	45	24		8	15	5	59, 7		21	5		5	0	20	33, 3
	47	21		10	19	7	30, 1		24	46		7	7	22	9, 9
	49	7		11	2	7	36, 3		30	12		10	12	24	23, 5
	51	55		12	11	8	35, 9		33	12		12	8	25	37, 5
	54	13		14	17	10	10, 4		35	41		14	19	27	22, 3
	56	15		15	3	10	22, 7		39	6		16	19	28	44, 6
	58	0		16	5	11	8, 0		42	25		18	19	30	6, 8
1	2	59		19	5	13	11, 4		46	31		20	7	31	4, 4

The quantity of the lucid part being now become ſo large, I prepared to obſerve the end : And with the ſame teleſcope which I uſed at the beginning, I obſerved the end of the eclipſe at 1$^{h.}$ 50′ 25″.

From

* I ſuſpect there muſt be ſome inaccuracy in theſe obſervations. Some months after, upon examining the micrometer with which they were taken, I found ſome parts of it had been diſplaced.

From these observations it may be inferred, that the greatest obscuration was at 12^{h.} 30′ 12″: At which time the sun's limb was reduced to so fine a thread, and so much broken as to be incapable of mensuration.

Professor Sewall observed with an achromatic telescope of 4 feet, made by *Dolland*, magnifying 40 times.

The beginning by his observation was at 11^{h.} 11′ 38″. The end was not accurately ascertained, being disturbed in his observations by some of the spectators.

Mr. Winthrop observed with a reflecting telescope, made by *Nairne*, magnifying 55 times.

The beginning by his observation was at	11^{h.}	11′	38″
Shadow touches the spots on the N. W. limb,		29	28
Spots totally immersed,		30	0
Shadow touches the first spot in the western limb,		44	6
central spot,		46	8
eastern spot,		47	9
End of the eclipse,	1	50	17 to 21″

D. Atkins observed the beginning and end of the eclipse with a reflecting telescope of 12 inches focus, made by *Short*, magnifying about 55 times. His other observations were made with the telescope which I used to observe the beginning and end of the eclipse. The following, is his account of his observations.

Beginning of the eclipse,	11	11	13

The

The ſhadow touched the center of a large ſpot		h	′	″
on the weſtern ſide of the ſun's diſc, - -		11	30	12
The ſhadow touched the center of a long cluſter of				
ſpots on the weſtern ſide of the ſun's center, - -			44	7
The ſhadow biſects the large ſpot in the ſun's center,			46	24
The ſpot on the eaſtern limb of the ſun half immerſed,		12	27	1
The ſpot on the eaſtern limb of the ſun half emerged,			40	18
The long cluſter of ſpots on the weſtern ſide of the				
ſun half emerged, - - - -			40	28
The central ſpot half emerged, - -		1	7	1
The ſhadow left the center of the ſpot on the weſtern ſide,			43	4
End of the eclipſe, - - - -		1	50	28

J. Davis obſerved with the teleſcope on the quadrant. It gives a very diſtinct viſion ; but it's magnifying power is but ſmall. His account of his obſervations is as follows.

Beginning, - - - -	11	11	16
Shadow firſt touched the largeſt ſpot in the cluſter			
on the N. W. limb, - - - -		29	10
wholly covered the ſame, -		39	9
Shadow firſt touched a large ſpot near the center of			
the ſun's diſc, - - - -		46	14
wholly covered it, - -		46	53
Firſt ſpot began to appear, - - -	12	39	54
wholly free of the ſhadow, - -		41	13
Central ſpot firſt appeared, - - -	1	6	25
free of the ſhadow, - -		7	14
Shadow leaves the ſun, - - -	1	49	58

To

To have a comparative view of the ſeveral obſervations, they are ſet down together in the following table.

Obſervers.	Beginning.	End.	Teleſcope made uſe of.	Magnifying power.
Mr. Williams,	11h 11′ 8″	1h 50′ 25″	2 feet reflector,	90
Mr. Sewall,	11 11 38		4 feet achromatic,	40
Mr. Winthrop,	11 11 38	1 50 17to21	1 foot reflector,	55
D. Atkins,	11 11 13	1 50 28	1 foot reflector,	55
J. Davis,	11 11 16	1 49 58	2½ feet achromatic,	ſmall.

Whilſt we were making the above obſervations, there was little wind, and no cloud to be ſeen. But the air was not perfectly clear, being a little thick, or hazy.

From the beginning of the eclipſe unto the time of the greateſt obſcuration, the *colour* and *appearance* of the ſky was gradually changing from an azure blue to a more dark or duſky colour, until it bore the appearance and gloom of night.

The degree of *darkneſs* was greater than was to be expected, conſidering the ſun was not wholly obſcured.—*Venus* appeared bright in the weſt; *Jupiter* was ſeen near the ſun; *Lucida Lyræ* near the zenith, and *Arideſ* in the north-eaſt near the horizon, appeared very bright. Several others of the fixt ſtars were alſo ſeen whoſe ſituations were not particularly noted. Objects at a ſmall diſtance appeared confuſed; and we were obliged to make uſe of candles to count our clock. But as ſoon as the greateſt obſcuration was paſt, it was univerſally remarked, that the increaſe of the light was much more rapid than that of the darkneſs had been.

As the darkneſs increaſed, a *chill* and *dampneſs* were very ſenſibly felt. To aſcertain the quantity of *dew* that fell on a ſquare

N foot,

foot during the eclipse, we cut two pieces of very fine soft paper, exactly twelve inches square. Having weighed them in a nice balance, we placed them on an horizontal board in the open air. Just after the greatest obscuration we weighed one of them again, and found it's weight was increased by the *dew* that had fallen upon it, $4\frac{1}{2}$ grains *troy*. At the end of the eclipse we took up the other, and found it's weight increased by the *dew* that lay upon it, but 3 grains; $1\frac{1}{2}$ grain being evaporated as the light and heat of the sun increased. By a similar experiment, the quantity of *dew* that fell upon a square foot the night before, was found to be $6\frac{1}{2}$ grains; the night after the eclipse, 7 grains. Thus in 1 hour and 19 minutes, when the light and heat of the sun were rapidly decreasing, there fell two-thirds as much *dew* as fell the night before, or the night after the eclipse.

To determine what alteration might take place as to *heat* or *cold*, we made the following observations on Farenheit's thermometer, which was hung up in the open air, on the north side of a tree.

Time.	Therm.	Time.	Therm.
10h. 0′	52°	12h. 16′	53°
24	$54\frac{1}{2}$	20	52
11 14	$57\frac{1}{2}$	25	51
21	58	33	50
26	58	42	48
44	58	45	49
49	57	1 24	51
56	$56\frac{1}{2}$	29	$52\frac{2}{3}$
12 1	56	32	54
3	55	37	55
11	54	54	58

To

To this we may add, so unusual a darkness, dampness and chill, in the midst of day, seemed to spread a general amazement among all sorts of animals: Nor could we ourselves observe such unusual phenomena without some disagreeable feelings.

THE LATITUDE OF THE PLACE,

Computed from the observed zenith distance of the sun's upper limb.

OCTOBER 20.

Zenith distance of the sun's upper limb,		54°44′15″
Refraction,	+	1 20
Sun's semi-diameter,	+	16 8
Sun's parallax in altitude,	—	7
Zenith distance of the sun's center,		55 1 36
Sun's declination, south,	—	10 44 22
Latitude, north,		44 17 14

OCTOBER 24.

Zenith distance of the sun's upper limb,		56 8 17
Refraction,	+	1 25
Sun's semi diameter,	+	16 9
Sun's parallax in altitude,	—	7
Zenith distance of the sun's center,		56 25 44
Sun's declination, south,	—	12 8 43
Latitude, north,		44 17 1

OCTOBER 25.

Zenith distance of the sun's upper limb,	56 28 56

 Refraction,

Refraction,	+	1′ 26″
Sun's semi-diameter,	+	16 10
Sun's parallax in altitude,	—	7
Zenith distance of the sun's center,		56° 46 25
Sun's declination, south,	—	12 29 21
Latitude, north,		44 17 4
Mean of the above,		44 17 6,33

The LATITUDE computed from the observed zenith distance of several stars.

Rigel.

Mean of zenith distances, taken Oct. 24 and 25,		52 43 45
Refraction,	+	1 14, 7
True zenith distance,		52 44 59, 7
Declin. S. Jan. 1, 1770, by *Greenwich Observ.*		8 29 0, 2
Decrease in 10 years and 299 days,	—	52,78
Aberration,	—	8,29
Nutation,	—	5,20
Apparent declin. south, Oct. 25, 1780,	—	8 27 53,93
Latitude, north,		44 17 5,77

Sirius.

Mean of zenith distances, taken Oct. 24 and 25,		60 40 57
Refraction,	+	1 41, 2
True zenith distance,		60 42 38, 2
Declin. S. Jan. 1, 1770, by *Greenwich Observ.*		16 24 56, 1
Increase in 10 years and 299 days,	+	45,97
Aberration,	—	11,04

Nutation,

Nutation,	—	6″,90
Apparent declin. south, Oct. 25, 1780,	—	16°25′24, 13
Latitude, north,		44 17 14, 07

Procyon.

Mean of zenith distances, taken Oct. 24 and 25,		38 29 32
Refraction,	+	45, 3
True zenith distance,		38 30 17, 3
Declin. N. Jan. 1, 1770, by *Greenwich Observ.*		5 47 55, 2
Decrease in 10 years and 299 days,	—	1 20, 58
Aberration,	+	4, 71
Nutation,	+	8, 10
Apparent declin. north, Oct. 25, 1780,	+	5 46 47, 43
Latitude, north,		44 17 4, 73
Mean of the above,		44 17 8, 19
Latitude from observations of the sun,		44 17 6, 38
Latitude from observations of the stars,		44 17 8, 19
Mean of both,		44 17 7, 26

In computing the latitude I have made use of the table of refractions inserted in the Greenwich observations. But from several observations I have reason to think that the refractions in *Penobscot-Bay* are not uniform and regular; but that they vary very much with the winds and weather in that uncultivated part of the country.

As to our longitude, I could have wished to have had some observations of the eclipses of Jupiter's satellites, and of the oc-

cultations of the fixed ſtars by the moon. But no obſervations of this kind could be made. Comparing my obſervation of the beginning and end of the eclipſe with obſervations made at *Cambridge*, *Chelſea*, and *Beverly*, and thence computing the difference of meridians, I find our obſervatory on *Long-Iſland*, was 9′ 20″ to the eaſt of *Cambridge*.

The longitude of the place of our obſervation agrees very well with what we had ſuppoſed in our calculations. But the latitude is near half a degree leſs than what the maps of that part of the country had led us to expect. On this account our ſituation, inſtead of falling within the limits of the total darkneſs, proved to be very near the ſouthern extremity.

10. Obſervations of a lunar eclipſe, November 11, 1780, at *Cambridge*.

The clock was regulated by equal altitudes of the ſun, taken by Mr. Gannett and Mr. Mellen. At $8^{h.}$ 40′, I meaſured the moon's diameter parallel to the horizon with an object-glaſs micrometer, and by a mean of ſeven obſervations, found it to be 30′45″,9.

Beginning of the eclipſe, by	
Mr. Williams, with an achromatic teleſcope magnifying 90 times,	Temp. app. $10^{h.}$ 21′ 9″
Mr. Gannett, with a reflector magnifying 55 times,	10 21 23
J. Dawſon, with a reflector magnifying 60 times,	10 21 37
End of the eclipſe, by	
Mr. Williams,	13 22 22
Mr. Gannett,	13 22 21
Mr. Mellen, with a reflector magnifying 55 times,	13 22 24

At

At the time of the greatest obscuration the quantity of the lucid part, as near as I could measure it with the micrometer, amounted to 5′ 39″, 2.—But this observation, and those made on the end of the eclipse, must be viewed as attended with some uncertainty. The shadow of the earth, throughout the whole eclipse, was very ill-defined: And from the middle to the end of the eclipse, the moon was partly obscured by very thin whitish clouds, which made it extremely difficult to distinguish the limits of the shadow, or the exact time when it left the moon's limb.

11. Observations of a lunar eclipse, March 28, 1782, at *Cambridge.*

Three gentlemen of the University observed this eclipse with me:—James Winthrop, Esq; Librarian, John Mellen, A. M. Mathematical Tutor, and Elijah Paine, A. B. The observations we made were as follow.—

Mr. *Williams's* observations.

	Temp. app.
Beginning of the eclipse,	14h 13′ 16″
Shadow reaches *Tycho,*	28 58
Grimaldus,	31 3
covers *Grimaldus,*	37 51
reaches *Copernicus,*	15 4 10
Mare Tranquillitatis,	8 40
Tycho appears,	16 26 27
leaves *Tycho,*	28 19
Mare Crisium,	29 25
End of the eclipse,	53 41
End of the penumbra,	55 51

These

Theſe obſervations were made with an achromatic teleſcope magnifying 90 times, made by *Nairne*. At $13^{h.}$ 30′, I meaſured the moon's horizontal diameter with an object-glaſs micrometer applied to a reflecting teleſcope of 12 inches focus, made by *Short*, and by a mean of five obſervations I found it 33′ 12″. The greateſt obſcuration was at $15^{h.}$ 34′ 33″, when the lucid part of the moon, meaſured by the micrometer, was 11′ 31″, amounting to 4 digits 11′: Whence the quantity of the eclipſe was 7 digits 49′.

Mr. *Winthrop's* obſervation.

	Temp. app.
Eclipſe began,	$14^{h.}$ 13′ 42″
Shade reached *Tycho*,	28 5
Tycho wholly eclipſed,	30 24
Grimaldus,	33 27
Grimaldus quite eclipſed,	37 42
Inſula Ventorum eclipſed,	59 22
Copernicus,	15 4 6
Cuſps horizontal,	48 59
Tycho begins to emerge,	16 26 6
quite out of the ſhade,	27 49
End of the eclipſe,	53 15
End of the penumbra,	53 45

Mr. Winthrop obſerved with a reflector, made by *Nairne*, fitted with vertical and horizontal wires, magnifying 55 times.

Mr.

Mr. *Mellen's* observation.

	Temp. app.
Beginning of the eclipse,	14^h^ 14′ 5″
Shadow first touched *Mare Humorum*,	22 43
Sinus Epidemarum,	23 44
Tycho begins to immerge,	27 7
wholly immerged,	28 34
Grimaldus begins to immerge,	31 41
wholly immerged,	37 51
Lausbergius begins to immerge,	49 46
Insula Ventorum begins to immerge,	53 21
Copernicus begins to immerge,	15 3 5
wholly immerged,	14 1
Mare Crisium begins to immerge,	27 51
Tycho begins to emerge,	16 25 51
wholly emerged,	28 21
Mare Crisium wholly emerged,	29 51
End of the eclipse,	54 36
End of the penumbra,	55 31

These observations were made with an achromatic telescope, made by *Dolland*, magnifying 40 times.

Mr. *Paine's* observation.

Beginning of the eclipse,	14 14 26
Shadow reaches *Grimaldus*,	32 16
covers *Grimaldus*,	35 59
reaches *Copernicus*,	15 2 54
Grimaldus begins to emerge,	38 23
is wholly emerged,	42 17

Tycho begins to emerge,	16^h 26′ 49″
is wholly emerged,	27 52
Mare Crisium wholly emerged,	29 18
End of the eclipse,	53 11
End of the penumbra,	56 11

Mr. *Paine's* observations were made with a reflector, made by *Short*, magnifying 55 times: But this was the first eclipse he had ever observed.

These observations were made at the house of Professor *Williams*. The times were shewn by an excellent astronomical clock, made by *Ellicott*, which was carefully regulated by corresponding altitudes of the sun. The weather was very favourable for observation.

In lunar eclipses the shadow is so imperfectly defined that the beginning and end can seldom be observed without an uncertainty of one minute, and sometimes of two or three minutes. In this eclipse, the circumstances were favourable for observation.

To have a comparative view of the several observations, those phenomena are set down in the following table, which were noted by each observer.

Phases observed by Mess'rs.	Williams,	Winthrop,	Mellen,	Paine.
Beginning of the eclipse,	14^h 13 16″	14^h 13′ 42″	14 14′ 5″	14^h 14′ 26″
Shadow reaches *Tycho*,	28 58	28 5	27 7	
Grimaldus,	31 3	33 27	31 41	32 16
covers *Grimaldus*,	37 51	37 42	37 51	35 59
reaches *Copernicus*,	15 4 10	15 4 6	15 3 5	15 2 54
Tycho begins to emerge,	16 26 27	16 26 5	16 25 51	16 26 49
wholly emerged,	28 19	27 49	28 21	27 52
Mare Crisium wholly emerged,	29 25		29 51	29 18
End of the eclipse,	53 41	53 15	54 36	53 11
End of the penumbra,	55 51	55 45	55 31	56 11

12. Observations

12. Obſervations of a ſolar eclipſe, April 12, 1782, at *Cambridge.*

We had not any compleat obſervation of the beginning of this eclipſe, being interrupted by ſmall fleeting clouds paſſing over the ſun. At 12$^{h.}$ 10′ 45″, I had a clear view of the ſun, and could not ſee any appearance of the eclipſe. At 12$^{h.}$ 11′ 15″, I diſcerned a darkneſs upon the weſtern limb, but could not determine whether it was occaſioned by a thin whitiſh cloud which was then paſſing over the ſun, or whether it was the beginning of the eclipſe. At 12$^{h.}$ 11′ 45″, the cloud left the weſtern limb, and it was apparent that the eclipſe began ſome time before. From theſe circumſtances I think it probable that the beginning of the eclipſe was very near 12$^{h.}$ 11′ 15″. Mr. *Paine* made the ſame remarks upon the beginning; but noted the darkneſs 5 or 6 ſeconds ſooner than I perceived it.

At the end of the eclipſe we had very good obſervations; the air being clear, and the ſky free from clouds. Theſe obſervations were as follow:

End of the eclipſe

By Mr. Williams, with an achromatic teleſcope magnifying 90 times,	Temp. app. 2$^{h.}$ 51′ 30″
By Mr. Winthrop, with a reflector magnifying 55 times,	2 51 28
By Mr. Mellen, with an achromatic teleſcope magnifying 30 times,	2 51 29
By Mr. Paine, with a reflector magnifying 55 times,	2 51 15

At 12$^{h.}$ I meaſured the ſun's horizontal diameter with an object-glaſs micrometer, fitted to a reflecting teleſcope, and by a mean of five obſervations found it 31′ 54″. At 1$^{h.}$ 34′, the obſcuration was the greateſt: The lucid part of the ſun was then 19′ 9″; whence, the greateſt eclipſe was 4 digits 48′.

13. Obſervations of a lunar eclipſe, September 10, 1783, at *Cambridge*.

The moon roſe behind a cloud that lay along the horizon. At 7$^{h.}$ 20′, I ſaw her totally eclipſed. The eaſtern part was of that duſky copper-colour which is uſual in total eclipſes: But the weſtern part was ſo obſcure as to be almoſt inviſible, except a circular appearance of light round her limb. At 7$^{h.}$ 27″, the clouds broke away, and I had a good obſervation of the

End of total darkneſs at	7$^{h.}$41′ 53″

In a few minutes the moon was again obſcured by clouds: But at 8$^{h.}$ 15′, they diſperſed and left a very clear ſky; after which I made the following obſervations:

Mare Serenitatis wholly emerged,	8	22	38
Mare Tranquillitatis wholly emerged,		31	3
Mare Criſium begins to appear,		31	33
bisected,		33	38
wholly emerged,		35	43
End of the eclipſe,		42	8

Theſe obſervations were taken with an achromatic teleſcope magnifying 90 times: But the ſhadow did not appear to be very diſtinctly defined.

Mr. Mellen, with a reflecting teleſcope magnifying 55 times, made the following obſervations:

End

	Temp. app.		
End of total darkneſs,	7h.	41′	48″
Langrenus wholly emerged,	8	34	4
End of the eclipſe,		42	3

Mr. Paine obſerved with an achromatic teleſcope magnifying 30 times. By his obſervation

The end of total darkneſs was at	7	42	18
Bright ſpot in *Mare Vaporum* wholly emerged,	8	14	28
Mare Tranquillitatis wholly emerged,		31	88
End of the eclipſe,		42	13

Both theſe gentlemen obſerved with me; and the times were taken by the ſame clock.

The laſt eleven eclipſes were all that could be obſerved in this part of *America*, from Jan. 1, 1770, to Jan. 1, 1784.

Obſervations of the eclipſes of *Jupiter's ſatellites*.

1782.		Temp. app.			
June	25,	9h.	48′	30″	Em. 2d ſatellite.
July	2,	12	21	54	Em. 2d ſatellite.
	3,	12	9	53	Em. 1ſt ſatellite.
Aug.	27,	9	6	25	Em. 1ſt ſatellite.
	28,	9	3	49	Em. 2d ſatellite.
Sept.	12,	7	31	29	Em. 1ſt ſatellite.

Theſe obſervations were taken with an achromatic teleſcope magnifying about 300 times. If they are compared with the calculations in the Nautical Almanac, the *mean* will give 4h. 44′ 36″ for the difference of meridians between the Royal Obſervatory at Greenwich, and the Univerſity at Cambridge in America.

Obſervations

Obſervations of the Tranſits of VENUS and MERCURY over the Sun, in the Years 1769, and 1782.

I. An obſervation of the tranſit of VENUS over the ſun, June 3, 1769, at *Newbury*.

The tranſits of Venus over the ſun are among the moſt uncommon and uſeful phenomena which aſtronomy ever preſents to our view. I had the happineſs of ſeeing that of 1761, at *St. John's*, in *Newfoundland*, attending the late excellent Dr. *Winthrop* in his voyage and obſervations at that place. That of 1769 I obſerved at *Newbury*, at the ſeat of *Triſtram Dalton*, Eſq; a gentleman of *Newbury-Port*.

The teleſcope I uſed was a reflector, made by *Nairne*, magnifying about 55 times; a good inſtrument, but not fitted with a micrometer, or with vertical and horizontal hairs, as I could have wiſhed. The clock was a very good one, and carefully adjuſted to apparent time by correſponding altitudes of the ſun.

The weather for ſeveral days before the tranſit had been dull and rainy; but the third of *June* proved favourable to our wiſhes. The air was uncommonly clear, and the ſky ſerene. About twenty minutes before the tranſit was expected, I began to keep my eye ſteadily fixed on that part of the ſun's limb on which the planet, by calculation, was to enter; an aſſiſtant, counting the clock in the mean time, while another ſtood by to write down the obſervations. Thus prepared, we waited with a kind of agreeable anxiety for the high ſatisfaction of ſeeing Venus on the ſun; a ſatisfaction I had once before enjoyed in viewing the tranſit of 1761, and which I knew muſt end

with

with that of 1769. A ſmall irregularity on the ſun's limb ſeemed to denote the approach or firſt appearance of the planet. At 2h. 30′ 14″ apparent time, I ſuſpected I ſaw *a ſmall diſturbance* on the ſun's limb: But the impreſſion was then ſo ſmall, irregular, and ill defined, that it was not till after ſeveral ſeconds that I was certain the tranſit was begun. The impreſſion increaſing and growing more diſtinct, I fixed on the time mentioned above as the time of the *external contact*. By obſervers, in the ſame ſtate of the atmoſphere, with teleſcopes and eyes equally good, and fixed on that part of the ſun on which the planet entered, I imagine this firſt impreſſion might have been obſerved to an agreement of five or ſix ſeconds.

Soon after Venus had firſt touched the ſun's limb, the whole of her diſc became viſible: She appeared circular, and was ſurrounded with a pale glimmering light, not very diſtinctly defined. From this appearance I concluded it would be impoſſible to fix upon the preciſe moment when her limb would be exactly coincident with that of the ſun, and therefore determined to wait till there ſhould appear a ſmall thread of light between them. As the *internal contact* drew near, the thread of light began to form, and ſeemed to dart on each ſide of the planet for ſeveral ſeconds without being fixed or ſettled. At 2h. 48′ 44″, with a ſeeming uncertainty of not more than ſeven ſeconds, it became cloſed and fixed. Venus then appeared wholly within the ſun, ſeparated from his limb by a fine ſtream of light flowing gently round it. This I fixed upon as the *internal contact*. Not having a *micrometer*, or hairs fixed in the reflector, inſtead of making any further obſervations, we could only enjoy the pleaſure

pleaſure of viewing this curious phenomenon, and ſhewing it to a number of gentlemen who had aſſembled on the occaſion.

In the above account of the *contacts* the duration of the ingreſs or paſſage of Venus over the ſun's limb, is 18′ 30″; near one minute longer than in moſt of the *American obſervations*. By theory it ſhould be 18′ 56″; but as this muſt have been contracted fifteen ſeconds by parallax at the place of obſervation, the apparent duration of the ingreſs would be but 18′ 41″; that is, eleven ſeconds longer than it was made by obſervation. I much doubt whether it was poſſible to diſcern the planet ſo ſoon as eleven ſeconds after the firſt contact, when not a ſecond of its diameter had entered upon the ſun. It ſeems more probable that the *internal contact* was paſt before the thread of light appeared to me to be compleated.

The latitude of the place where this obſervation was made is 42° 47′, north. With regard to it's longitude, the mean of ſix obſervations of the eclipſes of *Jupiter's ſatellites*, give it 1′ 26″ in time eaſt of *Cambridge*.

II. An obſervation of the tranſit of MERCURY over the ſun, November 9, 1769, at *Salem*.

The tranſits of Mercury, though they are not of equal uſe in aſtronomy as thoſe of Venus, are yet of great advantage to perfect the elements of his theory, and to determine the longitude of places on the earth. I had an opportunity to obſerve one of theſe tranſits at the houſe of *Andrew Oliver*, Eſq; at *Salem*.

The

The only inſtrument we could procure was a reflecting teleſcope magnifying about 60 times. To aſcertain the time I was obliged to make uſe of a *watch*, which for ſeveral days was carefully regulated by the ſun's paſſage over the meridian.—— Taking the minutes from the watch, I counted ſeconds from one minute to another. And from the pains I took to be exact, I believe the time was well pointed out this way, though ſuch as an Aſtronomer would by no means chuſe.

At $2^{h.}\ 54'\ 40''$ apparent time, Mercury came on the ſun's limb as it were in an inſtant, in the form of a clear, regular, well-defined black ſpot. The *internal contact* was equally inſtantaneous. At $2^{h.}\ 56'\ 0''$, the thread of light cloſed to appearance in a moment, without a ſeeming uncertainty of one ſecond. The ſky being perfectly clear and ſerene, nothing could be better defined than the limbs of Mercury and the ſun: But the teleſcope did not admit of any further obſervations, either of the diameters of the ſun and Mercury, or the leaſt diſtance of their limbs.

The latitude of *Salem* is 42° 35′ north; and it's longitude is about 1′ 15″ in time eaſt of *Cambridge*.

III. Obſervations of the tranſit of MERCURY over the ſun, Nov. 12, 1782, at the Univerſity in *Cambridge*.

Two gentlemen of the Univerſity obſerved this tranſit with me: *James Winthrop*, Eſq; Librarian, and *Elijah Paine*, A. B.

The inſtruments which I uſed in obſerving this tranſit, were an achromatic teleſcope made by *Nairne*, with a magnifying power of 150; a reflecting teleſcope fitted with an object-

glaſs micremeter made by *Short*, with a magnifying power of 60; and an aſtronomical clock made by *Ellicott*. To regulate the clock with the greateſt accuracy I took a large number of correſponding altitudes of the ſun every day the weather would permit from the beginning of *October*, and found by the moſt careful attention that it kept equal time very exactly: The greateſt error at any time not being more than two ſeconds in twenty-four hours.

On the 12th of November the weather was fair, but the air was not in the moſt favourable ſtate for obſervation. Viewing the ſun with an excellent achromatic teleſcope, I found the ſpots on the diſc well defined; but the limb appeared to have an irregular, tremulous motion. This tremor, or undulation of the ſun's limb, was of different degrees at different times; but it did not wholly ceaſe any part of the day.

At $9^{h.}$ 55′, I began to keep my eye ſteadily fixed on that part of the ſun's limb on which the planet was to enter; and at $10^{h.}$ 6′ 0′′ apparent time, I ſaw the firſt appearance of *Mercury*. The impreſſion ſeemed to be ſudden and inſtantaneous, and without any uncertainty as to the time. But the appearance was not like the contact of two circles, or like that of a well-defined black ſpot entering upon the ſun; but rather like a dark oval ſhadow inſtantly entering and mixing with the ſun's limb. Plate I. Fig. VIII. While Mercury was thus entering upon the ſun, no part of it was viſible but that which was within the ſun's diſc. It's figure appeared to be elliptical: The greater axis ſeemed to paſs through the point of contact, and to be about one-third longer than the other. This elliptical appearance of the planet made it impoſſible to determine when the

limbs

limbs of the ſun and Mercury exactly coincided. I therefore eſtimated the *internal contact* by the firſt appearance of a ſmall thread of light between them. This took place at 10$^{h.}$ 12′7″. The elliptical appearance was then wholly gone, and Mercury appeared circular, and perfectly well-defined. But the tremulous motion of the ſun's limb was then ſo great, that this obſervation ſeemed to be attended with an uncertainty of eight or ten ſeconds.

When Mercury was wholly within the ſun, I applied myſelf to the micrometer to meaſure the diameters of the ſun and Mercury, and the leaſt diſtance of their limbs. By a mean of eight obſervations taken during the tranſit, I found the ſun's horizontal diameter to be 32′ 21″, 85 : This was the ſame with the reſult of ſeveral ſimilar obſervations made a little before the tranſit began, and juſt after it ended. To aſcertain the diameter of Mercury, I made twelve obſervations at different times during the tranſit. The greateſt care was taken to have them accurate : And the mean of all the meaſures gave it 9″, 247.

In obſerving the leaſt diſtance of the limbs of the ſun and Mercury, I made the following obſervations :

Apparent time.			Leaſt diſt. of the limbs of ☉ & ☿.		
h.	′	″	°	′	″
10	31	53	0	0	12, 33
	30	16			16, 44
	41	22			18, 49
	45	49			22, 00
	47	0			22, 60
	48	32			22, 60
	54	42			18, 49
11	4	20			12, 00

I found considerable difficulty in meaſuring ſuch ſmall diſtances.—But the utmoſt attention was paid to theſe obſervations, as being ſome of the moſt uſeful and important of the whole: And I believe they were taken with as much exactneſs as the inſtrument would admit. Thoſe near the middle I eſteemed the moſt exact.

As Mercury approached the limb of the ſun I again uſed the achromatic teleſcope; and at $11^{h.}\ 23'\ 8''$, obſerved *the ſecond internal contact*. Mercury was then perfectly circular and well-defined; and the undulation of the ſun's limb leſs than before. This obſervation did not appear to me to be attended with an uncertainty of more than four or five ſeconds. While Mercury was paſſing the ſun's limb, it's form again appeared elliptical, and the ſame phenomena took place which were noted at the former contacts, but in a much leſs degree. Juſt before the end of the tranſit, the limbs of Mercury and the ſun appeared to be blended and mixed together. At $11^{h.}\ 29'\ 19''$, Mercury ſeemed inſtantly to break off, ſeparate, and diſappear. This obſervation I eſteemed the moſt exact of any I had made.*

To

* America was the moſt favourable place for obſerving this tranſit: And the undulation of the ſun's limb ſeems to have been greater, in ſome parts of Europe, than it was here. On ſuch accounts the American obſervations may be of much uſe in the records of aſtronomy. By a letter from M. DE LA LANDE, dated Paris, February 14, 1783, I find they have been viewed in this light by the ROYAL ACADEMY OF SCIENCES AT PARIS. "J'ai recu, Monſieur, avec une extreme ſatisfaction vos lettres "avec les obſervations qui y etoient renfermées. Je les ai preſentée a l' Academie "des Sciences, qui m'a chargé de vous en faire ſes remercimens, et qui les a deſtinées a l' impreſſion. J' ai donné meime au journal des ſavans votre obſervation du paſſage de Mercure, qui m'a fait d' autant plus de plaiſir que notre obſervation de Paris etoit fort douteuſe a cauſe de l' ondulation des bords du ſoleil."

To aſcertain the diameter of the ſun by other meaſures, about 12$^{h.}$ I made ſeveral obſervations of his paſſage over the meridian. Theſe obſervations were taken with a tranſit teleſcope, fitted with three vertical hairs. The times were ſhewn by a curious *watch*, which diſtinguiſhes to a quarter of a ſecond. The mean of ten obſervations gave 2′ 16″, 2, for the time of the ſun's paſſing the meridian. This, reduced to parts of a circle, and multiplied by the co-ſine of the ſun's declination, gives 32′ 24″, 20, for the ſun's apparent diameter.

Mr. *Winthrop's* obſervation.

The teleſcope Mr. Winthrop uſed was a large reflector, made by *Short*. It's apperture is eight inches, and it's focal diſtance forty-eight. It has four magnifying powers—120, 260, 380, and 500. The magnifying power Mr. Winthrop uſed was 260. With this he obſerved

	Temp. app.
The firſt external contact at	10$^{h.}$ 6′ 31″
The firſt internal contact at	12 13
The ſecond internal contact at	11 23 5
The ſecond external contact at	29 10

With regard to theſe obſervations it ſhould be noted, that the times in both our obſervations were taken by the ſame clock; but we obſerved at different parts of the houſe, and without any kind of communication together. The obſervations of the firſt external contact differ thirty-one ſeconds. Thoſe of the firſt internal contact are within ſix ſeconds. Thoſe of the ſecond internal contact differ but three ſeconds: And in thoſe of the laſt external contact there is no difference at all. The ob-

ſervation of the laſt external contact Mr. Winthrop ſuppoſes was attended with the greateſt certainty: And he noted thoſe optical phenomena which have been mentioned.

Mr. *Paine's* obſervation.

Mr. Paine uſed a reflector made by *Nairne*, magnifying 50 times. This teleſcope is fitted with vertical and horizontal hairs; and is ſo made that theſe hairs may be adjuſted to any ſituation; to obſerve differences of altitude and azimuth, or thoſe of right aſcenſion and declination.

By his obſervation, the firſt external contact was at 10^h. 7′ 7″. The internal contact was not accurately noted.

During the tranſit, he made the following obſervations of the difference of right aſcenſion between the limbs of the ſun and Mercury: The hairs in the focus of the reflector being ſo placed that the upper limb of the ſun appeared to move along one hair, and of conſequence, the other was perpendicular to the Equator.

	Temp. app.
1.	
Sun's preceding limb at the hair,	10^h. 25′ 50″
Mercury's center at the ſame,	27 35
Sun's ſucceeding limb at the ſame,	28 6
2.	
Sun's preceding limb at the hair,	32 49
Mercury's center at the ſame,	34 32d
Sun's ſucceeding limb at the ſame,	35 6
3.	
Sun's preceding limb at the hair,	48 36
Mercury's center at the ſame,	50 13
Sun's ſucceeding limb at the ſame,	50 53

Sun's

4.	Temp. app.
Sun's preceding limb at the hair,	11^h. 1′ 58″
Mercury's center at the ſame,	3 30
Sun's ſucceeding limb at the ſame,	4 15
5.	
Sun's preceding limb at the hair,	5 41
Mercury's center at the ſame,	7 11
Sun's ſucceeding limb at the ſame,	7 57
6.	
Sun's preceding limb at the hair,	13 59
Mercury's center at the ſame,	15 26
Sun's ſucceeding limb at the ſame,	16 15
Laſt internal contact,	22 5
Laſt external contact,	28 6

In reſpect to Mr. *Paine's* obſervations of the contacts we may remark, that they appear to have been carefully made, notwithſtanding they differ ſo much from thoſe made with much larger teleſcopes. The difference in the obſervations evidently aroſe from the difference of teleſcopes. Mercury was ſeen with an achromatic magnifying 150 times, 1′7″ ſooner at the firſt contact, and 1′ 13″ later at the laſt contact, than it was with this ſmall reflector. The mean of theſe, 1′ 10″, may be taken as the difference which aroſe from the difference of teleſcopes in obſerving ſo ſmall an object as Mercury, in ſuch a ſtate of the atmoſphere. Allowance being made for this difference, Mr. Paine's obſervations of the contact will be found to agree as well with the other obſervations of the contact, as they do with each other. The obſervations of the differences of right aſcenſion would be very little affected by this cauſe, and therefore do not want any correction.

From

From theſe obſervations it will be eaſy to compute all the circumſtances of this tranſit, and the principal elements of the theory of Mercury.

Thus, Plate I. Fig. IX. let the circle ÆAQ repreſent the ſun; NS the ecliptic; ÆQ a parallel to the equator; VA the apparent path of Mercury; NE part of Mercury's orbit. SA is a perpendicular to the equator; SE a perpendicular to the ecliptic; and SM a perpendicular to Mercury's viſible way. The middle of the tranſit will be when Mercury arrives at the point M; the ecliptical conjunction at E; and the conjunction in right aſcenſion at A: And N will repreſent the place of Mercury's aſcending node.

The middle of the tranſit is given by the obſervations of the contacts. This,

	Temp. app.
By my obſervations of the external contacts, was at	$10^{h} 47' 39'',5$
By thoſe of the internal contacts,	10 47 37, 5
My Mr. Winthrop's obſ. of the internal contacts,	10 47 39
The mean of which may be aſſumed as moſt exact,	10 47 38,66

The viſible conjunction of the ſun and Mercury in right aſcenſion, may be deduced from Mr. Paine's obſervations of their differences, &c. The reſult of theſe obſervations, as I have deduced them from calculation, are as follow:

Obſ.	App. Time.	Difference R. A. of ☉'s center, and ☿ in Time.	Diff. R. A. in Parts of a Circle reduced to the Equator.	Time of Conjunction of ☉ and ☿ in Right Aſcenſion.
1	$10^{h} 27' 35''$	$37''$	$8' 48'', 2$	$12^{h} 5' 55''$
2	34 32d	34, 5	8 12, 3	12 5 15
3	50 13	28, 5	6 46, 8	12 5 59
4	11 3 30	23, 5	5 35, 4	12 5 58
5	7 11	22	5 14, 0	12 5 40
6	15 26	19	4 31, 3	12 5 57
			Mean,	12 5 57, 33

The

The apparent diameters of the ſun and Mercury are alſo determined by obſervation.

By the micrometer meaſures, Mercury's diam. was	9″,247
The diam. of the ſun by the microm. meaſures was	32′ 21, 85
By the time of it's paſſing the meridian,	32 24, 20
The mean of which may be taken as moſt exact,	32 22, 96

The leaſt diſtance of centers is alſo had from obſervation.

By the micrometer meaſures this was	15 43, 70

To examine the obſervations made by the micrometer, I computed by trigonometry what the leaſt diſtance of centers would be by calculation from the obſervations of the contacts. The reſult gives the leaſt diſtance

By my obſervations of the external contacts,	15 44, 1
By thoſe of the internal contacts,	15 43, 5
By Mr. Winthrop's obſerv. of the internal contacts,	15 43, 6
The mean is the ſame as by the micrometer,	15 43, 73

From the obſervations of the diameters and leaſt diſtance of centers, we may compute the length of the apparent tranſit-line, and Mercury's viſible horary motion from the ſun. In the right-angled triangle S*Mm*, we have SM the leaſt diſtance of centers, and S*m* the ſum of ſemi-diameters. Multiply the the ſum of S*m* and SM by their difference, the ſquare root of the product will be the length of M*m*. By ſuch a calculation (all the circumſtances of the obſervations being taken into conſideration) the length of the tranſit-line, eſtimated

By the external contacts, is	496″,2
By the internal contacts, is	423, 0

And hence,

By proportion, ☿'s viſ. horary mot. from the ſun was	5′ 57, 33

From these *data* we may determine the angle of Mercury's visible way with the ecliptic, the geocentric latitude, and the time of the ecliptical conjunction. In the right-angled triangle SMA, SM is given, and MA is known by the visible horary motion of Mercury from the sun. Hence, we can find SA, and the angle MSA 26° 13′ 28″. ESA is the angle made by that parallel to the Equator which passes through the sun's center at the ecliptical conjunction, and the ecliptic; and is equal to the sun's declination at that time, 17° 52′ 55″. Subtract this angle from MSA, and we have the angle MSE, the angle of Mercury's visible way with the ecliptic, 8° 20′ 33″. Again, in the right-angled triangle SME, we have SM, and the angle MSE; from which we can find SE and ME. The former is the geocentric latitude, and the latter is the difference between the middle of the transit and the ecliptical conjunction. By such a calculation corrected by parallax, at the ecliptical conjunction the geocentric latitude of Mercury was 15′ 56″, 8: And the time of ecliptical conjunction, Nov. 12$^{d.}$ 11$^{h.}$ 10′ 58″.

In the above calculation, the parallax of Mercury from the sun at the ecliptical conjunction, is supposed to be 3″, 09 in latitude, and 1″, 50 in longitude.

The geocentric latitude and the angle of Mercury's visible way with the ecliptic being known, we can also determine the place of Mercury's node, and the inclination of his orbit to the plane of the ecliptic. If we assume Mercury's distance from the earth to be 67683, and his distance from the sun 31198, his heliocentric latitude at the ecliptical conjunction will be 34′ 36″; his horary motion in the ecliptic, 15′ 18″, 21; and his horary motion in the ecliptic from the sun, 12′ 47″, 01.

Then

Then, in the the right-angled ſpherical triangle VSE, SE and the angle VES are known; from which we can find the ſide SV, 3° 55′ 33″. If this be increaſed in the ratio of 12′ 47″, 01 to 15′ 18″, 21, we ſhall have the ſide SN, Mercury's diſtance from the node, 4° 41′ 59″. Subtracting this from 7^S. 20° 26′ 36″ the ſun's place at the time of ecliptical conjunction, (by Mayer's tables) we ſhall have the place of Mercury's aſcending node in ♉, 15° 44′ 37″.

Again, in the right-angled ſpherical triangle SNE, the ſides SE and SN are given: From theſe we can find the angle SNE the inclination of Mercury's orbit to the plane of the ecliptic, 7° 0′ 13″.

In computing the place of Mercury's node and the inclination of his orbit, the calculation chiefly depends on the angle of Mercury's viſible way with the ecliptic. This may be computed from the obſervations of the *contacts*. But a very ſmall error in thoſe obſervations, will produce a very conſiderable one in the deductions. It was therefore thought beſt to deduce it from the obſervations of *right aſcenſion*, which are equally convenient, and more numerous.

V. *Some select Astronomical Observations made at* Chelsea, *Latitude* 42° 25′, *and* 26″ *in Time East of the University at* Cambridge. *By the Rev.* PHILLIPS PAYSON, *F. A. A.*

THE use of astronomical observations, to promote the purposes of navagation and geography, must be evident to every person that has paid any proper attention to the subject. By comparing observations made in different places, it is well known, special advantages accrue; and by transmiting those of one age down to another, affords astronomers, in future time, great helps for improvement: And no doubt but improvements will be made in this divine science to the end of time.

The extensive territories of the United States of *America*, are a foundation in nature for a vast empire.—The geography of its interior parts, though of great importance, is, at present, but little better than conjectural: To perfect which, and fix the interesting boundaries and lines, the best, and indeed the only proper method is, that of astronomical observations, which, it is probable, the Supreme Council of *America* will soon adopt, now the glorious revolution is so happily compleated. To promote such observations, both at noted head-lands upon the sea-coast, and at distant places in the interior country, highly merits the attention of this Academy: For though they should not at first be made with such accuracy as modern astronomy can boast of, they will prove great helps for future improvements.

The mode of observation, to determine the latitude of a place, is of very easy acquisition: Nor is that difficult which settles its longitude, if a person can be furnished with a good time-piece,

Hadley's

Hadley's quadrant, and a tolerable teleſcope. The eclipſes of Jupiter's ſatellites being ſo frequent, and of ſuch eaſy obſervation, they prove very favourable phenomena for this purpoſe.

But where great accuracy is required, a ſolar eclipſe or an occultation of a ſtar by the dark ſide of the moon, are to be prefered.

Several places in this and ſome other ſtates in the union, have been determined in reſpect to each other, with much preciſion, from obſervations of late years. Such as ſhall be made in future, may correct ſome errors of the preſent.

The following obſervations were made with much care and attention. The clock was an excellant good one, regulated by equal altitudes of the ſun taken by reflection with *Hadley's* quadrant: It was counted by a perſon much uſed to the thing; and in all of them, ſpecial care was taken in adjuſting the equation of equal altitudes for the decreaſe or increaſe of the ſun's declination.

The glaſs uſed, is a reflecting teleſcope, made by *Nairne*, better than 2 feet in length, and magnifying about 55 times. In a clear air, it ſhows the ſatellites of Jupiter to be nearly of the bigneſs of ſtars of the firſt magnitude.

Emerſions of Jupiter's ſatellites in the year 1779.

1ſt. Sattelite.	App. Time.	2d. Satellite.	App. Time.
April 22,	$10^h\ 37'\ 3''$	May 29,	$8^h\ 58'\ 00''$
May 8,	8 57 19	June 30,	8 39 15
15,	10 52 7	3d. Satellite.	
June 23,	9 16 40	May 16,	8 54 20
		23,	12 52 40
		June 28,	8 36 1

Obſervations

Observation of a solar eclipse, June 24, 1778.

	App. Time.
Beginning, A. M.	9h. 6' 42"
Middle,	10 21 55
End exact,	11 38 23

Observation of a lunar eclipse, May 29, 1779.

Immersion ☽'s S. E. limb,	10 15 44
Ditto ☽'s N. W. limb,	11 31 16
Emersion ☽'s N. E. limb,	12 50 42
Ditto ☽'s S. W. limb,	14 5 55

Observation of a solar eclipse, October 27, 1780.

Beginning,	11 00 58
Immersion of four spots, nearly in a line, just above the ☉'s center. Spot 1st. Plate II. Fig. I.	11 33 6
2d.	11 34 15
3d.	11 35 6
4th.	11 36 18
Immersion of a large spot nearly in the ☉'s center.	
Beginning,	11 36 18
Spot covered, i. e. end,	11 37 20
Emersion of the four spots above the ☉'s center.	
Spot 1st.	12 53 3
2d.	12 54 23
3d.	12 55 5
4th.	12 56 9
Emersion of the large spot near the ☉'s center.	
Beginning,	12 56 44
Compleated,	12 57 45
Eclipse ended,	1 40 37
Duration,	2 39 39

At

At 11^{h.} 15′, mercury in the thermometer ſtood at 59°.—It ſank gradually; and at 12^{h.} 30′, ſtood at 51°.—Then gradually roſe to 59°, at 1^{h.} 15′. A little before 12^{h.}, there appeared a large halo, or circle, around the ſun, and continued for ſome time.

Obſervation of a lunar eclipſe, November 11, 1780.

	App. Time.
Beginning,	10h. 27′ 15″
End,	1 18 50
Duration,	2 51 35

Obſervation of a ſolar eclipſe, April 12, 1782.

Beginning not obſerved, the face of the ſun being covered with clouds.	
Correct app. time of the end of the eclipſe, P. M.	2 52 21

Obſervation of a tranſit of Mercury over the ſun, November 12, 1782.

Firſt ext. contact obſerved a few ſeconds too late,	10 7 41
Firſt internal ditto,	10 12 36
Second internal ditto,	11 23 31
Second external ditto,	11 28 58
Duration of the tranſit,	1 21 17

VI. *Observation of the Transit of Mercury over the Sun, November 12, 1782, at* Ipswich. *By the Reverend* MANASSEH CUTLER, *F. A. A.*

CORRESPONDING altitudes of the sun were taken with a sextant, made by *Nairne* and *Blunt*, for regulating my clock, before and after the transit, viz.—On the 7th of Nov. were taken eight set of the upper, and nine set of the lower limb :—On the 8th, twelve set of the upper, and ten set of the lower limb :—On the day of the transit, eighteen set of the upper, and fourteen set of the lower limb, taken at different intervals :—On the 14th, nine set of the upper, and eleven set of the lower limb :—On the 15th, six set of the upper, and eight of the lower limb ;—and on the 18th, seven set of the upper, and nine set of the lower limb. The equation of declination was added to each set of altitudes. By the result, found my clock went with great uniformity, but gained 7″ 33‴ in twenty-four hours.

The day of the transit was clear and pleasant, with very little wind. My observation was made with a reflecting telescope, magnifying 45 times.

By an unfortunate accident, I failed of seeing the first external contact. At the time of the first internal contact, the sun's limb was exceedingly well-defined ; but at the second internal and external contacts, the undulation of the limb was considerable.

	App. Time.
First internal contact,	10ʰ 13′ 37″
Second ditto ditto,	11 24 15
Second external ditto,	11 30 20

VII. *A Memoir, containing Obſervations of a Solar Eclipſe, October* 27, 1780, *made at* Beverly: *Alſo of a Lunar Eclipſe, March* 29, 1782,—*of a Solar Eclipſe, April* 12, *and of the Tranſit of Mercury over the Sun's Diſc, November* 12, *the ſame Year, made at the Preſident's Houſe in* Cambridge. *By the Rev.* JOSEPH WILLARD, *Preſident of the Univerſity.*

Obſervations of a ſolar eclipſe, October 27, 1780, at *Beverly*.

I ATTENDED to my clock for a number of days before the eclipſe, but more particularly on the 25th, 26th and 27th. On each of thoſe days, the ſtate of the atmoſphere was favourable for taking correſponding altitudes of the ſun. I took a number of double altitudes, both of his upper and lower limb, in the forenoon and afternoon, with *Hadley's* octant, by reflection from a bowl of very clear oil of tar, which was of ſuch a conſiſtence as to prevent undulation from the air, and in which, the ſolar image was extremely well defined. I noted the times by the clock, when the limbs of the two images of the ſun juſt came into contact. The conjunction of the centers I did not attempt to take, becauſe it cannot be determined with a certainty equal to the contact of the limbs.

The equation for the change of the ſun's declination, during the half interval between the forenoon and afternoon obſervations, was conſtantly applied.

Obſervations of correſponding double altitudes of the ſun, October 25.

	Foren. obſ.	Aftern. obſ.	Intervals.	½ Intervals.	Noon per clock nearly.
Sun's upper limb.	8h 35′ 2″	3h 22′ 46″	6h 47′ 44″	3h 23′ 52″	11h 58′ 54″
	8 39 40	3 18 8	6 38 28	3 19 14	11 58 54
	8 42 0	3 15 47	6 33 47	3 16 53½	11 58 53½
	8 44 23	3 13 25	6 29 2	3 14 31	11 58 54

	Foren. obs.	Aftern. obs.	Intervals.	½ Intervals.	Noon per clock nearly.
Sun's lower limb.	8h 50′ 46″	3h 7′ 5″	6h 16′ 19″	3h 8′ 9½″	11h 58′ 55½″
	8 55 32	3 2 16	6 6 44	3 3 22	11 58 54
	9 0 24	2 57 30	5 57 6	2 58 33	11 58 57
	9 2 48	2 55 8	5 52 20	2 56 10	11 58 58

Time of noon nearly by the clock, by a mean of the above eight obs.	11 58 55
Equation for change of declination in the ½ interval,	+ 16
Exact time by the clock, when ☉'s center passed the meridian,	11 59 11
Hence, the clock too slow for apparent time at noon,	49

In like manner observations were made on the 26th and 27th, the result of which it is sufficient to put down.

On the 26th,

When the sun's center passed the meridian, it was, by the clock, allowing for the equation,	11h 58′ 16″
Hence, the clock too slow for app. time at noon,	1 45

On the 27th,

When the sun's center passed the meridian, it was, by the clock,	11 57 18
Hence, the clock too slow for apparent time at noon, on the day of the eclipse,	2 42
Loss of the clock, respecting apparent time, between the noon of the 25th and 26th,	56
Ditto, 26th and 27th,	57

In the morning of the 27th, the Reverend Mr. *Cutler*, of *Ipswich*, and the Reverend Mr. *Prince*, of *Salem*, favoured me with their company, to observe the eclipse with me. Mr. *Cutler* and I were each furnished with a reflecting telescope, made by *Mann*, of *London*. The magnifying power of Mr. *Cutler's*, was 34, and that of mine, 45 times. Mr. *Prince's* telescope was an achromatic refractor of 3 feet. It's original magnifying power was 16½; but he increased it to 43 times, by taking out the third glass of the sliding-tube, and adding another eye-glass of

of about an inch focus. We determined the magnifying power of our telefcopes by *Hawkfbee's* method.

We fat down to our telefcopes about ten minutes before eleven o'clock, in a garden adjoining the room where the clock was fixed, and were fo fituated, that we could all very diftinctly hear the perfon who counted the clock. Before we began to obferve, we agreed that each one fhould note his times of obfervation, without fpeaking to the others, that all might determine for themfelves, and no one might be in danger of being difconcerted.

We had a favourable time for obferving the beginning and end of the eclipfe. The immerfions and emerfions of a number of the folar fpots were attended to by us; the fituations of which, upon the difc, we determined as near as we could, a little while before we fat down to our telefcopes. They then appeared to us as in Plate II. Fig. II. Mr. *Prince* had fixed parallel hairs in his refractor, dividing the fun's difc into four equal parts, horizontally. Thefe hairs, together with a vertical one in the center, affifted us much in fettling the places of the fpots.

As we had no micrometer to meafure the magnitude of the eclipfe, we determined it by Dr. *Wallis's* method, publifhed in *Whifton's* Aftronomical Lectures, p. 188, 189. The eclipfed parts of the fun, marked at the time of the greateft obfcuration, we afterwards meafured upon a diagonal fcale drawn for the purpofe, by which we could determine to the fiftieth part of a digit.

At the middle of the eclipfe, and for fome time before and after it, there was a very great chilnefs in the air, and fo much dew fell, that the papers we ufed abroad became quite damp.

The following are our obfervations of this eclipfe, adjufted to apparent time.

	Mr. *Willard.*	Mr. *Cutler.*	Mr. *Prince.*
Beginning of the eclipfe,	11h 1′ 48″	11h 1′ 42″	11h 1′ 46″
Immerfions of the weftern edges of folar fpots.			
No. 1, of the weftern fpots,	11 22 31	11 22 28	11 22 41
No. 1, of the north-eaftern fpots,	11 33 31	11 33 23	11 33 25
No. 3, of ditto,	11 35 21	11 35 22	11 35 23
A large fpot near the center,	11 36 56	11 36 54	11 36 57
A fouth-eaftern fpot neareft the vert. diam.		12 11 34	12 11 37
Emerfions of the eaftern edges of folar fpots.			
No. 2, of the weftern fpots,		12 31 55	12 31 56
No. 1, of the north-eaftern fpots,	12 53 50	12 53 47	12 54 4
No. 2, of ditto,	12 54 53	12 54 57	12 55 0
No. 3, of ditto,	12 55 36	12 55 36	12 55 41
No. 4, of ditto,	12 56 32	12 56 31	12 56 38
The large fpot near the center,	12 58 6	12 58 4	12 58 14
The end of the eclipfe,	1 41 26	1 41 23	1 41 29
The duration,	2 39 38	2 39 41	2 39 43

By our obfervation, the greateft obfcuration was at about 12h 21′, apparent time, when the parts eclipfed were 11 dig. 24′

The clock's rate of going was the fame for feveral days following the 27th, as it had been for the two days preceding.

N. B. 1. By twenty-feven double altitudes of the fun, when upon the meridian, taken with a *Hadley's* octant, very accurately conftructed, I have found the latitude of the houfe, where the foregoing obfervations were made, 42° 36′ N.——The houfe ftands facing the middle of the training-field, (fo called) in the firft parifh in *Beverly*.

N. B. 2. By calculations from the obfervations of the foregoing eclipfe made at *Beverly*, and thofe made at *Chelfea*, I find the difference of meridians to be 45″ in time; which, added to 26″, the difference between *Chelfea* and *Cambridge*, makes 1′ 11″ for the difference between *Cambridge* and *Beverly*. The difference between *Beverly* and *Penobfcot*, where Profeffor *Williams* and company made their obfervations, I find, in the fame

way,

way, to be 8′ 4″, which makes the difference between *Cambridge* and *Penobſcot* 9′ 15″. The difference between *Beverly* and *Providence*, by deductions from the obſervations, is 2′ 18″, which gives 1′ 7″ between *Cambridge* and *Providence*.

Obſervations of a lunar eclipſe, March 29, 1782, made at the Preſident's houſe in *Cambridge*.

The going of my clock was aſcertained, for the obſerving of this eclipſe, in the ſame manner as for the foregoing one of October 27, 1780.

Mr. *Caleb Gannett* obſerved the eclipſe with me. The teleſcope I made uſe of was an achromatic refractor, with a magnifying power of 90. Mr. *Gannett* made uſe of a reflecting teleſcope, of about the ſame magnifying power. We had, upon the whole, a pretty favourable time; though the earth's ſhadow, at the moon, did not appear ſo well defined as we could have wiſhed.*

The obſervations follow.

		Apparent Time. By Pref. *Willard.*	Apparent Time. By Mr. *Gannett.*
Beginning of the eclipſe,		2h 14′ 7″	2h 14′ 0″ A. M.
Shadow touches	*Harpalus,*	22 51	22 57
	Tycho,	27 21	27 10
covers	*Tycho,*	29 16	29 4
touches	*Mare Criſium,*	3 28 49	3 28 10
leaves	*Mare Criſium,*	4 28 36	4 28 17
leaves	*Mare Tranquilitatis,*	33 40	34 7
End of the eclipſe,		4 53 50	4 53 33

Obſervations

* In obſervations of different lunar eclipſes, when the ſtate of the atmoſphere, as far as the eye could determine, has been the ſame, the earth's ſhadow has appeared much better defined in one, than in another.

Obſervations of a ſolar eclipſe, April 12, 1782, made at the Preſident's houſe.

The going of my clock was aſcertained in the ſame manner as at the time of the lunar eclipſe, in March.

Mr. *Caleb Gannett* and Mr. *William King* obſerved the eclipſe with me. Mr. *Gannett* and I had the ſame teleſcopes that we uſed for obſerving the lunar eclipſe. Mr. *King* was furniſhed with a good reflecting teleſcope, the magnifying power of which was about 40. At the beginning of the eclipſe the clouds were troubleſome; ſo that the entrance of the moon upon the ſun's limb was not ſeen by us, or by any of the obſervers in *Cambridge*. But the clouds diſperſed ſoon afterwards, and the atmoſphere became perfectly clear; ſo that we had a very favourable time for obſerving the end of the eclipſe, which was,

	Apparent Time.
By Preſident *Willard*, at	$2^h\ 51'\ 41''$ P.M.
Mr. *Gannett*,	2 51 27
Mr. *King*,	2 51 41

As we were not furniſhed with a micrometer, no other obſervations, of any conſequence, were made by us upon this eclipſe.

Obſervations of the tranſit of Mercury over the ſun's diſc, November 12, 1782, made at the Preſident's houſe.

The going of my clock was determined, for this phenomenon, as for the eclipſes, in the ſpring.

Mr. *Caleb Gannett* obſerved with me. We were furniſhed with the ſame teleſcopes that we made uſe of for obſerving the eclipſes. Our obſervations were as follow.

Apparent Time.

	1ſt ext. cont.	1ſt int. cont.	2d int. cont.	2d ext. cont.
By Pref. *Willard*,	$10^h\ 6'\ 27''$	$10^h\ 12'\ 37''$	$11^h\ 23'\ 2''$	$11^h\ 29'\ 32''$ A.M.
By Mr. *Gannett*,		10 12 45	11 23 36	11 29 29
Mean,		10 12 41	11 23 19	11 29 $30\frac{1}{2}$

	—10h 12′ 41″	—10h 6′ 27″
Duration of the transit,	internal 1 10 38	ext. 1 23 3½

The state of the atmosphere was unfavourable, during the transit. The limb of the sun appeared serrated; so that it was difficult to determine the contacts, with that precision which could be wished.

At the time of the first internal contact, and for some minutes after, the limb of ☿, next to the sun's eastern limb, had an oval appearance; and his limb, next to the western limb of the sun, put on the same appearance, a few minutes before, and at the time of the second internal contact.

For ☿'s horizontal parallax.

☿'s distance from the earth 67681 : the sun's distance from the earth 98879 :: the sun's horizontal parallax 8″, 55 : ☿'s horizontal parallax 12″, 49. Therefore, ☿'s horizontal parallax from the sun is 3″, 94.

Elements for calculating ☿'s parallax from the sun in latitude and longitude, at *Cambridge*, at the first external contact, November 12, 1782, at 10h 6′ 27″, A. M. apparent time.

The sun's longitude,*	7s 20° 23′ 53″, 304
Mercury's geocentric longitude,	7 20 30 12, 078
Mercury's geocentric latitude, north,	14 55, 754
The sun's right ascension,	227 57 5
The right ascension of the mid-heaven,	199 33 50
Angle answering to *p*PZ in Plate I. Fig. I.	70 26 10
The sun's horary motion,	2 31, 2
Mercury's geo. hor. mot. in long. in the ecliptic retro.	3 22, 32

Mercury's

* The elements of the sun are calculated from *Mayer's*, and those of Mercury from M. de la *Lande's* tables.

Mercury's geo. hor. mot. from the sun in the eclipitc,	5′ 53″, 52	
Mercury's geo. hor. motion in latitude increasing,	51, 96	
The sun's semi-diameter,	16 12, 2	
Mercury's semi-diameter,	5, 1	
Mercury's horizontal parallax from the sun,	3, 94	
The obliquity of the ecliptic,	23° 28 12	
The lat. of *Cambridge* reduced to the center,	42 8 37	

Hence,

The altitude of the nonagesimal degree,	44 24 32
The longitude of the nonagesimal degree,	$5^{s.}$ 26 45 44
Mercury's parallax in latitude from the sun,	2, 807
Mercury's parallax in longitude from the sun,	2, 224

At the second external contact, at $11^{h,}$ 29′ 30½″, A. M. apparent time; by calculation,

Mercury's parallax in latitude from the sun,	3, 169
Mercury's parallax in longitude from the sun,	1, 280

The longitude of the nonagesimal degree, at the time both of the first and second external contact, being less than the longitude of Mercury, the parallax in longitude is to be added to Mercury's longitude, in each, to give the visible; and as Mercury's motion in transits is retrogade, and the parallax at the time of the second external contact was greater than at the time of the first, the length of the visible transit-line was greater than the true, by the difference of the parallaxes.

The true latitude, at each contact, was diminished by the parallax in latitude; and as the geocentric latitude was increasing, and the parallax, at the time of the second external contact, greater than at the time of the first, the visible motion in latitude was less than the true, by the difference of the parallaxes.

Plate I
Facing p. 136
Fig. I
Fig. VI
Fig. VII
Fig. VIII
Fig. II
Fig. III
Fig. IV
Fig. V
Fig. IX
335.9
1930.3
1954.3

☿'s parallax in longitude from ⊙, 1st ext. cont.	2″,224
Ditto, 2d,	1, 280
Difference,	0, 944
☿'s parallax in latitude from ⊙, 1st,	2, 807
Ditto, 2d,	3, 169
Difference,	0, 362
☿'s true mot. on ⊙'s disc in $1^{h.}\ 23'\ 3\frac{1}{2}''$ reduc. to the ecl.	8′ 9, 376
Difference of parallaxes in longitude,	+ 0, 944
Length of the vis. transit-line reduced to the ecliptic,	8 10, 320
	= 490″, 32
☿'s true motion in latitude in $1^{h.}\ 23'\ 3\frac{1}{2}''$,	1 11, 928
Difference of parallaxes in latitude,	— 0, 362
Visible motion in latitude,	1 11, 566
	= 71″, 566

For the angle of Mercury's visible way with the sun in the ecliptic; the error of the tables in latitude; and the time of the ecliptic conjunction of ⊙'s and ☿'s centers, deduced from the times of the external contacts.

In Plate II. Fig. III. let EDK represent half of the sun's disc; the diameter E⊙K a portion of the ecliptic, or rather a parallel to it;* ☿U a parallel = 490″, 32 Mercury's visible motion upon the sun's disc, reduced to the ecliptic; UM Mercury's visible motion in geocentric latitude, during the time between the two external contacts; consequently, M☿U, the angle required, and ☿M the visible transit-line; the point ⊙ the sun's center, at the apparent time of the visible conjunction of centers; ⊙N, perpendicular to ☿M, the visible least distance of centers; ⊙D perpendicular to the ecliptic, the visible dis-

* The distance from the ecliptic being equal to the sun's parallax in latitude.

tance of centers, at the time of the visible ecliptic conjunction; ☿☉ and M☉ the distance of centers, at the time of the external contacts, = the sum of the semi-diameter of the sun and of Mercury = 977″, 3; C☿ the visible difference of latitude of the centers, at the time of the first external contact; LM the visible difference, at the time of the second; C☉ = ☿F the visible difference of longitude of the centers, at the time of the first; and ☉L at the time of the second external contact.

For M☿U, the angle of Mercury's visible way.

☿U 490″, 32 : UM 71″, 566 :: Radius : Tangent angle M☿U 8° 18′ 15″.

For ☿M, the visible transit line.

Sine M☿U 8° 18′ 15″ : UM 71″, 566 :: Radius : ☿M 495″, 512. As ☿☉ and M☉ are equal, the perpendicular ☉N bisects ☿M; therefore, ☿N and NM are 247″, 756 each.

For angle ☿☉N.

☉☿ 977″, 3 : Radius :: ☿N 247″, 756 : Sine angle ☿☉N 14° 41′ 7″. Add angle N☉D = M☿U 8° 18′ 15″, the sum is = angle ☿☉D = ☿☉F = ☉☿C = 22° 59′ 22″; the complement of which is = angle ☿☉C = 67° 0′ 38″.

For side C☿ = Mercury's visible latitude from sun, at the first external contact.

Radius : ☉☿ 977″, 3 :: Sine angle ☿☉C 67° 0′ 38″ : C☿ 899″, 68 = 14′ 59″, 68; to which add the parallax in latitude 2″, 807, and the sum 15′ 2″, 487 is Mercury's true latitude by observation, at the time of the first external contact.

For side C☉, the visible difference of longitude of the centers of the sun and Mercury, at the time of the first external contact.

Radius : ☉☿ 977, 3 :: Sine angle ☉☿C 22° 59′ 22″ : C☉ = ☿F 381″, 696; from which subtract 2″, 224, Mercury's

parallax

parallax in longitude from the ſun, becauſe his viſible longitude was greater than the true, and the remainder, 379″, 472, will be the true difference of longitude.

For the apparent time of the true ecliptic conjunction, and Mercury's true latitude by obſervation.

Mercury's ecliptic horary motion upon ☉'s diſc 353″, 52 : 1^h = 3600″ :: the true difference of longitude 379″, 472 : 3864¼″, the ſpace of time from the firſt external contact to the ecliptic conjunction, = 1^h 4′ 24¼″; which, added to 10^h 6′ 27″, gives 11^h 10′ 51¼″, for the apparent time of the true ecliptic conjunction.

In 1^h 4′ 24¼″, Mercury's geocentric latitude was encreaſed 55″, 774; which, added to 15′ 2″, 487, his latitude at the firſt external contact, makes 15′ 58″, 261, for Mercury's true latitude by obſervation, at the time of the true ecliptic conjunction, by the external contacts.

Deductions from the internal contacts.

Let the references be to Plate II. Fig. III. the lines ☉☿ and ☉M being ſuppoſed = the difference of the ſemi-diameters of the ſun and Mercury = 967″, 1; and, conſequently, the tranſit-line wholly within the ſun's diſc.

☿'s parallax in longitude from ☉,	1ſt int. cont.	2″, 158
Ditto,	2d,	1, 355
Difference,		0, 803
☿'s parallax in latitude from ☉,	1ſt,	2, 837
Ditto,	2d,	3, 145
Difference,		0, 308

☿'s true mot. on ☉'s disc in $1^{h.}$ 10′ 38″ reduc. to the ecli.	6′ 56″, 171
Difference of parallaxes in longitude,	+ 0, 803
Length of the vis. transit-line reduced to the ecliptic,	6 56, 974
	= 416, 974
☿'s true motion in latitude in $1^{h.}$ 10′ 38″,	1 1, 168
Difference of parallaxes in latitude,	— 308
Visible motion in latitude,	1 0, 86
	= 60, 86

Hence,

M☿U, the angle of Mercury's visible way 8° 18′ 15″; —☿M, the visible transit-line, 421″, 392;—angle ☿☉N 12° 35′ 1″, consequently, ☿☉D = ☿☉F = ☉☿C 20° 53′ 16″, and angle ☿☉C 69° 6′ 44″;—side C☿, Mercury's visible latitude from the sun, at the time of the first internal contact, 903″, 543 = 15′ 3″, 543; which, added to the parallax in latitude from the sun, 2″, 837, gives 15′ 6″, 38, for Mercury's true latitude by observation, at the time of the first internal contact; —the side C☉, the visible difference of longitude of the centers of the sun and Mercury, 344″, 809; which, lessened by the parallax in longitude from the sun, 2″, 158 gives 342″, 651 for the true difference of longitude; which, converted into time, gives 58′ 9½″. This added to $10^{h.}$ 12′41″, A. M. gives $11^{h.}$ 10′ 50½″, for the apparent time of the true ecliptic conjunction.

In 58′ 9½″, Mercury's geocentric latitude was increased 50″ 365; which, added to 15′ 6″, 38, his latitude at the first internal contact, gives 15′ 56″, 745, for Mercury's true latitude by observation, at the time of the true ecliptic conjunction, by the internal contacts.

The

The apparent time of the true ecliptic conjunction, by the external contacts, being $11^{h.}\ 10'\ 51\frac{1}{4}''$, and by the internal ones $11^{h.}\ 10'\ 50\frac{1}{2}''$, let us call the time $11^{h.}\ 10'\ 51''$, when Mercury's latitude, by the former, must have been 15′ 58″, 257, and by the latter, 15′ 56″, 752, the mean of which, 15′ 57″, 504, may be called Mercury's true latitude by observation, at the time of the ecliptic conjunction. By M. de la *Lande's* tables it was 15′ 51″, 524; so that the error in the tables, by this mean, is — 5″, 98.

For Mercury's heliocentric latitude, according to the observed geocentric latitude.

Mercury's distance from the sun, 31198 : Mercury's distance from the earth 67681 :: Mercury's geocentric latitude at the ecliptic conjunction, by observation, 15′ 57″, 504 = 957″, 504 : Mercury's heliocent. lat. by observation, 2077″, 2 = 34′ 37″, 2.

For the place of the ascending node by observation.

Let ☊E, in Plate II. Fig. IV. be a portion of the ecliptic; the point ☊ the place of ☿'s ascending node; ☊☿ a portion of ☿'s heliocentric orbit; the point at ☿ his heliocentric place in his orbit, at the time of the ecliptic conjunction, and E his place reduced to the ecliptic; E☿ his heliocentric latitude; the angle E☊☿ the inclination of his orbit, by modern Astronomers generally determined to be 7° 0′ 0″. In the right-angled spheric triangle E☊☿, right-angled at E, there are given the angle E☊☿, and the perpendicular or side E☿, to find the base or side ☊E.

Radius,		
: Tang. E☿ or ☿'s heliocentric lat.	34′ 37″, 2	8 0030458
:: Tang. Co-inclination ☿'s orbit,	83° 0 0	10 9108562
: Sine base ☊E or ☿'s dist. from asc. node,	4 42 16	8 9139020

As

As Mercury's heliocentric motion was in the order of the ſines, and he had paſſed the node, ſubtract this diſtance from his heliocentric longitude, and the remainder will be the point ☊ of the ecliptic, or place of Mercury's aſcending node.

Mercury's heliocentric longitude,	1ˢ	20°	26′	36″
Subtract ☿'s diſtance from ☊,		4	42	16
Place of ☿'s aſcending node by obſervation,	1	15	44	20
Ditto by M. de la *Lande's* tables,	1	15	45	54

VIII. *Obſervations of a Solar Eclipſe, October 27, 1780, made at* St. John's *Iſland, by Meſſ'rs.* CLARKE *and* WRIGHT. *In a Letter from Mr.* JOSEPH PETERS *to* CALEB GANNET, *A. M. Rec. Sec. Amer. Acad.*

Halifax, (Nova-Scotia) 27th *Auguſt* 1781.

SIR,

SOME time in the beginning of this ſummer, Mr. *Winſlow* ſhewed me a paragraph of a letter from you, requeſting him, if he could, to obtain the minutes of ſome obſervations of the eclipſe of the ſun, which happened the 27th of October, 1780. I am ſo unfortunate as not to have any kind of apparatus for obſervations of that ſort; nor is there, that I know of, in this place, any thing of the kind,—theſe things, however uſeful, as well as pleaſing, being very little attended to in this place.

Since the ſaid application from Mr. *Winſlow*, I have received from my friend, Doctor *John Clarke*, who was educated in your College, ſome minutes of an obſervation of the fore-mentioned eclipſe, made by himſelf and a Mr. *Wright*, at *Charlotte-town*, on the iſland of *St. John*, in the gulph of *St. Laurence*. I take the liberty to incloſe you a copy of them.

Dr. *Clarke* ſays, that the obſervation was made with a reflecting teleſcope, two feet long, and compleatly fitted for the purpoſe. A clock was regulated with great accuracy, by means of double altitudes of the ſun, taken on ſeveral days before and on the day of the eclipſe. The obſervers were deficient only in a micrometer to meaſure the quantity. They eſtimated it at 11 digits.

Charlotte-town,

Charlotte-town, by obſervations of Mr. *Wright*, is in latitude 46° 13′ north, and 62° 50′ weſt longitude from *London*.

This obſervation agrees well with the beſt judgment I could frame of this eclipſe, at *Halifax*, by a good watch, regulated by the beſt time pieces here, to as great exactneſs as was in my power; except the quantity, which muſt be ſomething greater here, than at the iſland. I projected this eclipſe to be 11 dig. 30′ here, and by the beſt obſervations I could make, that was very nearly its real quantity.

I am aſſured by Mr. *Pool*, of *Yarmouth-Jebouge-Harbour*, on the weſtern coaſt of this province, that the eclipſe there was total for a momentary ſpace.

This, Sir, is the beſt account I am able to give concerning the phaſes of this eclipſe in theſe parts; which, if it prove uſeful in ſcience, or ſatisfactory to you, I ſhall think myſelf happy in having the opportunity of communicating it.

The town of *Halifax*, from obſervations of Mr. *Deſbarres*, is in 44° 44′ north latitude, and 63° 30′ 30″ weſt longitude from *London*.

I am, Sir, your moſt obedient
And very humble ſervant,
JOSEPH PETERS.

To Mr. *Caleb Gannett*.

The following are the obſervations made by Meſſ'rs. *Clarke* and *Wright*:

	App. Time.
Beginning of the eclipſe,	11ʰ 41′ 35″ A.M.
☽'s ſouthern limb at letter *a*, Plate II. Fig. V.	11 56 30
Ditto in contact with *b*,	12 59 2

☽'s

	App. time.
☽'s western limb quitted *d*,	$1^{h.}28'38''$ A.M.
Ditto quitted *b*,	1 35 13
End of the eclipse,	2 17 41
Duration,	2 36 6

They missed the contacts with *c* by altering the position of the telescope.

IX. *Obſervations of a Solar Eclipſe, October* 27, 1780, *made at the Univerſity in* Cambridge. *Communicated by* Caleb Gannett, *A. M. Rec. Sec. Amer. Acad.*

ON ſeveral days previous to the eclipſe, I carefully took correſponding altitudes of the ſun, with an excellent *Hadley's* quadrant. The agreement between the obſervations was ſuch, that thoſe taken on the two immediately preceding days, expreſs the reſult of the whole. They were as follow :

Oct. 25, A. M.		P. M.		
	8h 59′ 19″	2h 50′ 1″	Hence, at app. noon the clock was	11h 54′ 40″
	8 56 1	2 53 11	Interval	5 57 40
	8 52 10	2 57 18	½ ditto	2 58 50
			Equation of ½ intervals	+ 16
Sum,	26 47 30	8 40 30		
				11 54 56
Mean,	8 55 50	2 53 30		
			Clock ſlow of ſun,	5 4

Oct. 26, A. M.		P. M.		
	8 48 1	3 1 18	Hence, at app noon the clock was	11 54 36
	8 52 11	2 57 1	Interval	5 56 8 36‴
	8 56 47	2 52 23	½ ditto,	2 58 4 18
	9 0 58	2 48 11	Equation of ½ interval	+ 16
	9 4 42	2 44 29		
				11 54 52
Sum,	44 42 39	14 23 22		
			Clock ſlow of ſun,	5 8
Mean,	8 56 31 48‴	2 52 40 24‴		

On the 27th, obſervations were taken in the morning ; but the atmoſphere was ſo loaded with vapour, as to prevent the taking of any, with accuracy, in the afternoon.

From the above obſervations it appears, that between the 25th and 26th of October, the clock gained on mean time 2″. Hence, on the 27th, at apparent noon, the clock was ſlow of the ſun 5′ 11″. Two common braſs reflecting teleſcopes were uſed upon the occaſion, each magnifying about 60 times ; alſo, an

an achromatic, made by *Dolland*, it's magnifying power 90. The Reverend Profeſſor *Wiggleſworth* and Mr. *John Mellen*, uſed two of the teleſcopes. Mr. *Mellen* obſerved with the achromatic.

The obſervers were ſo unfortunate as not to perceive the beginning of the eclipſe. They ſuppoſed the ſhadow would have entered the ſun's diſc more weſterly than it did.—They therefore attended to a different part of the ſun's limb. To prevent a ſimilar error in future, it might be well, previouſly, to determine the point at which an eclipſe will commence. This may be done by calculating the angle, which the ecliptic will make with a vertical circle paſſing through the centre of the ſun, at the time the eclipſe begins.

The obſervations were as follow, viz.

Obſervers,	Wiggleſworth.	Gannett.	Mellen.	Mean of obſ.
	Apparent Time.			
	h. ′ ″	h. ′ ″	h. ′ ″	h. ′ ″
Firſt contact of N. W. ſpots, Plate II. Fig. VI.	11 20 57		11 21 3	11 21 0
Total obſcuration of ditto,	11 25 15		11 25 36	11 25 25½
Firſt cont. of N.E. ſpots, No. 1,	11 31 36	11 31 53	11 31 38	11 31 42⅓
2,		11 33 4		11 33 4
3,		11 33 54		11 33 54
Total obſcuration of 4,	11 34 52		11 34 58	11 34 55
Firſt cont. of central ſpot,	11 35 26	11 35 30	11 35 30	11 35 28⅔
Total obſcuration of ditto,	11 36 19	11 36 4	11 36 14	11 36 12⅓
Firſt cont. of S. E. ſpot,		12 13 47	12 13 47	12 13 47
Total obſcuration of ditto,		12 14 3	12 14 4	12 14 3½
Total emerſion of N. W. ſpots,	12 29 28			12 29 28
Firſt app. of N. E. ſpots, No. 1,	12 52 56	12 52 33	12 52 31	12 52 36⅔
2,		12 53 27		12 53 27
3,		12 54 9		12 54 9
Total emerſion of 4,	12 55 23		12 56 4	12 55 43½
Firſt app. of central ſpot,		12 56 11		12 56 11
Total emerſion of ditto,	12 56 47	12 56 45		12 56 46
Firſt app. of S. E. ſpot,		1 33 51	1 33 47	1 33 49
Total emerſion of ditto,	1 34 1	1 34 5		1 34 3
End of the eclipſe,	1 39 51	1 39 47	1 39 50	1 39 49⅓

Digits eclipſed, about $11\frac{2}{5}$.

The obſervers not being poſſeſſed of a micrometer, Mr. *Wiggleſworth* made uſe of the following expedient to determine

 the

the quantity of the eclipſe.—He deſcribed on paper a number of circles, dividing a common diameter into digits. The paper was placed perpendicular to a teleſcope, through which the ſun's rays were received upon it. Accuracy is not pretended in this method. The quantity noted, is the neareſt that could be eſtimated by it.

Through want of croſs wires in either of the teleſcopes uſed, the preciſe ſituation of the ſpots, on the ſun's diſc, could not be determined. In the figure, their relative ſituation is marked, according to judgment at the time.

X. *An Observation of a Solar Eclipse, October* 27, 1780, *at* Providence. *By* JOSEPH BROWN, *Esquire.*

MY apparatus for the observation of the solar eclipse was a three-feet reflecting telescope, with spirit levels; a small graduated semi-circle of about $4\frac{1}{2}$ inches radius, and rack motions for taking altitudes; and a glass micrometer, fitted with rack motions, I believe of *Dolland's* construction, having a nonius graduated to $\frac{1}{500}$ part of an inch: A reflecting telescope of near two feet; and a prospect-glass of three feet four inches length, which I mounted on a convenient stand.

On the 20th, I moved my clock into a convenient part of my house; and from that time to the day of the eclipse, I was constantly employed in taking corresponding altitudes of the sun with my telescope, and constructing a meridian-line.

Our observations of the eclipse were as follow:

The beginning was not accurately noted.

	h	′	″
First seen in correct time,	10	58	8
Just touches a black spot in or near the middle of a macula at the right hand,	11	21	32
Just touches the first of four spots all nearly in a range in a macula at the left hand,	11	30	52
Ditto the spot nearest the centre of the sun's disc,	11	35	20
The end of the eclipse as seen by Mr. *West* in the small telescope,	1	39	1
Ditto by my brother in the spy-glass,	1	39	8
Ditto last seen by myself in the largest reflector.	1	39	16

I

I took the diameter of the ſun while the eclipſe was on, and made it three inches and $\frac{434}{500}$; which, by my table, conſtructed in the year 1769, previous to the tranſit of Venus, makes the ſun's apparent diameter 32′ 18″: And the ſmalleſt I ſaw the bright part of the ſun was $\frac{140}{500}$ of an inch: So ſmall I am certain it was, and it might probably be a very little leſs, tho' I believe this to be pretty exact; and this, I think, makes the ſun to be 11 digits and $\frac{3}{10}$ eclipſed, or very nearly ſo.

XI. *Observations of the Solar Eclipse of the 27th of October, 1780, made at* Newport, Rhode-Island, *by Monf. de* GRANCHAIN. *Translated from the* French, *and communicated by the Reverend President* WILLARD.

	Times per Clock. h.	′	″	True Times. h.	′	″
THE instant when it was perceived that the eclipse had began,*	9	24	32	11	0	12
Preceding limb of the sun at the vertical,	11	21	39	0	57	27
Upper limb of the sun at the horizontal,		21	54		57	42
Upper horn at the horizontal,		22	3		57	51
Limb of the moon at the vertical,		22	45		58	33
Upper horn at the vertical,		23	7		58	55
Lower horn at the vertical, doubtful,		23	35		59	23
Lower horn at the horizontal,		29	31	1	5	20
Lower limb of the sun at the horizontal,		31	2		6	51
Preceding limb of the sun at the vertical,	11	37	12	1	13	1
Upper limb of the sun at the horizontal,		37	59		13	48
Upper horn at the horizontal,		38	32		14	21
Limb of the moon at the vertical,		passed,				
Upper horn at the vertical,		38	57		14	46
Lower horn at the vertical,		39	19		15	8
Lower horn at the horizontal,		43	38		19	28
Lower limb of the sun at the horizontal,		45	27		21	17

N. B. The apparent upper and lower limb of the planet, in the telescope of the quadrant, which inverts objects, is here called the upper and lower limb.

Preceding

* When it was perceived that an impression was made upon the limb of the sun, the eclipse had been begun 1′ 20″; therefore, the true beginning was at 10h 58′ 52″.

Preceding limb of the ſun at the vertical,	11h 47′ 8″	1h 22′ 58″
Upper limb of the ſun at the horizontal,	48 17	24 7
Limb of the moon at the vertical,	49 0	24 50
Upper horn at the vertical,	49 5	24 55
Upper horn at the horizontal,	49 7	24 57
Lower horn at the vertical,	49 21	25 11
Lower horn at the horizontal,	52 52	28 42
Lower limb of the ſun at the horizontal,	55 2	30 52
End of the eclipſe,	0 4 50	1 40 41
Latitude of the obſervatory upon *Goat-Iſland*,		41° 30 30

Obſervations of the lunar eclipſe of the 11th of Nov. 1780, made at *Newport*, (*Rhode-Iſland.*) By Monſ. de GRANCHAIN.

	Times per Clock.	True Times.
Beginning of the eclipſe,	7h 40′ 5″	10h 24′ 39″
Beginning of the immerſion of *Grimaldus*,	48 50	33 25
End of the immerſion of *Grimaldus*,	51 25	36 10
Beginning of the immerſion of *Tycho*,	8 0 36	10 45 12
The ſhadow of *Galileo*,	3 42	48 18
Beginning of the immerſ. of *Copernicus*,	27 54	11 12 31
End of the immerſion of *Copernicus*,	32 35	17 12
The ſhadow at the middle of *Dionyſius*,	46 55	31 33
The ſhadow at *Promontorium acutum*,	55 42	40 21
Copernicus begins to emerge,	9 17 54	12 2 34
Grimaldus begins to emerge,	22 2	6 42
Copernicus wholly emerges,	23 35	8 15
Grimaldus wholly emerges,	26 45	11 26
Promontorium acutum emer. from the ſhad.	51 12	35 55
Tycho wholly emerges from the ſhadow,	10 10 6	54 51
End of the eclipſe,	32 10	1 16 57

The

The ſame clock and quadrant were made uſe of in this obſervation, which had been uſed for the obſervation of the ſolar eclipſe. The going of the clock was, however, a little different, becauſe it had been altered.

ILLUSTRATIONS OF THE OBSERVATION OF THE SOLAR ECLIPSE.

The clock which was made uſe of to obtain the times, had a compound pendulum-rod, made by Monſ. *Berthoud*, a celebrated clock-maker at *Paris*. It was regulated many days before and after the obſervation, by correſponding altitudes, taken with a quadrant made by *Ramſden*, which was very good and very well divided.

The ſame quadrant was uſed in obſerving the tranſits of the horns, and of the limbs of the ſun and of the moon, acroſs the horizontal and vertical wires of the teleſcope, which was fitted for this purpoſe.

The obſerver, who, in putting on board the aſtronomical inſtruments, had nothing in view but the regulation of marine watches, was not ſo well provided with teleſcopes, as with time-pieces and quadrants. To obſerve the beginning and end of the eclipſe, he was obliged to make uſe of a ſimple achromatic ſea-glaſs, of three and an half feet focus. However, he believes he may anſwer for the end of the eclipſe, within four or five ſeconds nearly. The inſtant of the beginning is much more uncertain. A conſiderable impreſſion was made upon the ſun, before it was perceived. To determine, at leaſt, roughly, the true inſtant of the beginning of the eclipſe, an eſtimation was made, as near as might be, of the diſtance of the horns, at the moment when it was perceived that an impreſſion

was made upon the disc of the sun; and towards the end of the eclipse, it was observed how much time passed from the instant when the distance of the horns was sensibly the same, to the end of the eclipse. It is in this manner that it was determined, that about 1′ 20″ must have intervened, between the true instant of the beginning of the eclipse, and the time when the impression was first observed.

At first it was thought useless to endeavour to observe the quantity of the eclipse with the quadrant, because of the slowness of the motion of the two planets vertically; however, upon reflection, it was thought that the transits of the horns, and of the limbs of the sun and moon across the vertical wire only, would be sufficient to give the differences of the altitudes and azimuths of the centers of the two planets, and, consequently, their differences of latitude and longitude. These were, therefore, observed towards the end of the eclipse, and at the same time, the transits across the horizontal wire were observed, but without hoping that they could be of any great advantage, for calculating the distance of the centers.

In the first observation, the transit of the apparent lower horn across the horizontal wire is a little doubtful: It may therefore be proper to perfer, in the calcule from this observation, the transit of the limb of the moon, and of the apparent upper horn, across the same vertical wire.

In the second observation, the instant of the transit of the limb of the moon across the vertical wire was omitted, through hurry:—To calculate it, therefore, we may make use of the transit of the horn across the same wire.

The last observation, being more complete, we may calculate it by the one or the other method, indifferently; or we may

may make uſe of the tranſits acroſs the horizontal wire, to deduce the difference of altitude, becauſe the motion of the two planets, vertically, was become leſs ſlow, when this obſervation was made.

If we would, in the firſt obſervation, verify the inſtant of the tranſit of the apparent lower horn acroſs the vertical wire, or know, in the ſecond obſervation, the inſtant of the tranſit of the limb of the moon acroſs the ſame wire, we may eaſily calculate them, with the aſſiſtance of the quantities already known. It will, perhaps, be uſeful to make this calculation, that we may be in a condition of determining the variation, which muſt have taken place, in the poſition of the two planets, obſerved relatively the one to the other, during the ſpace of time which intervened, between their tranſits acroſs the ſame wire.

XII. *An Account of the Obſervations made in* Providence, *in the State of* Rhode-Iſland, *of the Eclipſe of the Sun, which happened the* 23d *Day of April,* 1781. *By* BENJAMIN WEST, *Eſquire, F. A. A. Communicated by the Reverend Preſident* WILLARD.

I HAVE thought proper to draw up a particular account of this eclipſe, as well knowing that proper obſervations of eclipſes make an important article in the theory of aſtronomy. It was by theſe kind of obſervations the lunar theory was bro't to it's preſent degree of perfection: And every Aſtronomer knows of what conſequence it is to navigation, to have the moon's motion ſettled to a certain degree of accuracy.

This eclipſe was obſerved in *Providence* by Mr. *Joſeph Brown* and myſelf, at Mr. *Brown's* houſe. The morning of the 23d of April was cloudy, and I deſpaired of ſeeing the ſun that day; but a little before twelve o'clock, the clouds ſeemed to break, and the ſun, now and then, made it's appearance, which gave me ſome hopes of ſeeing ſome part of the eclipſe: But after twelve o'clock the ſun was again obſcured by the clouds, and remained ſo till five or ſix minutes after the firſt contact of the ſun's and moon's limb, when we had again a ſlight view of the ſun through the clouds, and ſaw the eclipſe was coming on. The air continued unfavourable to our obſervation till a few minutes before the middle of the eclipſe, when the ſun again appeared, and gave us a good opportunity of obſerving the quantity of the eclipſe when at the greateſt;—for which purpoſe, Mr. *Brown* applied the micrometer, and found the lucid part of the ſun, when in its leaſt ſtate, 1288 microme-

ter meaſure. This was not done at a ſingle operation, but by a number of trials, till he found the bright part of the ſun was in it's leaſt ſtate. After reading off the numbers from the micrometer for the quantity of the eclipſe, Mr. *Brown* immediately, at my requeſt, took the length of the chord joining the cuſps, which I believe was done with great care, and found it 1380. The micrometer meaſures for the ſun's diameter was 1906. Then 1906 — 1288 = 618, the eclipſed part, and $\frac{618 \times 12}{1906} = 3^\circ\ 53'$ digits for the greateſt quantity of the eclipſe. From the table which we made for the micrometer in the year 1769, the ſun's apparent diameter was 31′ 53″, exactly agreeing with what *Mayer's* tables make it. I found the apparent diameter of the moon by the following method:—Let GFI be the ſun, and HEB the moon, and EF the chord joining the ſun's cuſps. Now, as BG is a ſtraight line, biſecting the ſtraight EF at right-angles, it muſt therefore paſs through the centers both of the ſun and moon. (*Euclid* 1. III.) The angle ADE is a right-angle, and AE and ED are given quantities. Then $\sqrt{AE^2 - DE^2} = AD$. (Per *Euclid* 47. I.)

AE =	953	
DE =	690	
Sum =	1643	3.2156376
Difference =	263	2.4199557
		2)5.6355933
AD =	657,2	2.8177966
AG =	953	
DG =	1610,2	
GH =	1288	
HD =	322,3	

The

The angle BEH, in a ſemi-circle, is a right-angle, (*Euc.* 31. III.) and HD, DE, DB, are three proportionals, (*Euc.* 8. VI.) that is to ſay, HD : DE :: ED : DB.

DE =	690	2.8388491
		× 2
		5.6776982
HD	322,3	2.5082603
BD =	1477,2	3.1694379

HB = 1299,5 the micrometer meaſure for the moon's diameter. It is a thing well known to mathematicians, that the ſines of ſmall arcs are nearly equal to the arcs themſelves; hence we have a rule to find the moon's apparent diameter by proportions.

☉'s micrometer meaſure	1906,	Log.	3 2801
It's ∠,	31′ 53″,	LL	7517
☽'s micrometer meaſure	1799,5	6° ar.	6 7449
☽'s apparent diameter,	30′ 6″,	LL	7767
Deduct	— 23 for the moon's elevation.		
☽'s horizontal diam.	29 43,		

but one ſecond more than what is given from *Mayer's* tables.

Mr. *Brown* and myſelf both noted the ſame ſecond for the laſt contact, which was at 2^h 53′ 36″ apparent time. There were ſome thin white clouds about the ſun, yet I think the obſervation was pretty good.

XIII. *Account of the Transit of Mercury, observed at* Cambridge, *November* 12, 1782. *By* JAMES WINTHROP, *Esquire, F. A. A.*

THE following observations were made at the house of the Reverend Professor *Williams*. We used the same clock, but observed the transit from different parts of the house. The clock was regulated by the Professor, who reduced all the observations to apparent time. Mine were as follow:

First external contact,	10h 6′ 31″ A. M.
First internal contact when the thread of light was formed, and Mercury recovered his roundness,	10 12 13
Mercury begun to appear oblong before the second internal contact,	11 21 41
Doubtful whether the thread of light was broken,	11 22 44
Second internal contact when the thread of light was compleatly broken,	11 23 5
Second external contact,	11 29 19

The magnifying power of the reflecting telescope used in these observations, was 260. The elliptical appearance of the planet was observed by Mr. *Williams* as well as myself, at both passages over the sun's limb; but I do not recollect to have seen it remarked of any former transit of this planet. An idea that the smallness of Mercury's apparent diameter and the rapidity of his motion would not suffer it to be of any long continuance, prevented my making more particular remarks at the time of the ingress. The certainty of a sufficient interval be-

tween

tween the laſt contacts, enabled me to attend more particularly to this obſervation at the end, than at the beginning of the tranſit. At $11^h 21' 41''$ apparant time, Mercury began to appear diſtorted; and from this time the thread of light grew gradually fainter till $11^h 22' 44''$, when I was doubtful whether it exiſted any longer. I ſet down the ſecond internal contact at $11^h 23' 5''$, when I was firſt certain that the thread of light was broken. From the time that the center of the planet appeared to me to have paſſed the ſun's limb, the appearance of it's following half became very irregular, being diſturbed by a briſk undulatory motion, which continued till the end of the tranſit.

This diſtortion appears to be common to both the inferior planets, when in the ſame ſituation with reſpect to the obſerver. At the tranſit of Venus in 1761, it was obſerved in *India*, *England* and *Sweden*; and at that of 1769, by almoſt all who obſerved the tranſit. They indeed vary in their ideas of its duration; which cannot be wondered at when we conſider the different magnifying power of their inſtruments, and the different ſtrength of their eyes. Particular deſcriptions of the appearance of Venus, in her two tranſits, are publiſhed in Vols. LIX. LX. and LXI. of the PhiloſophicalTranſactions, with ſuitable projections; and from the great reſemblance they bear to the appearance of Mercury in his laſt tranſit, the concluſion is natural that they aroſe from the ſame cauſe.

The object is ſo ſmall and remote, that we can hardly expect to determine it's cauſe with abſolute certainty. It will not, however, be deemed amiſs to remark, as a *probable* cauſe only, that the rays proceeding from ſo ſmall an object as that part of the ſun's limb which is neareſt to the planet, during the diſtortion of the latter, are too feeble to make a full impreſſion

preffion on the feat of vifion. Objects feen by reflection, as moft terreftrial bodies are, cannot be feen diftinctly, unlefs they fubtend a certain angle. The fame thing taking place in luminous objects, with a fmaller angle, when the thread of light becomes too fmall to be diftinctly feen, the exterior limb of the planet will appear confufed ; and every degree of confufion, arifing from a partial defect of light, will operate upon the eye like a real diftortion of the object. If this opinion be right, as the diftance of centers is eafily calculated for any given moment, perhaps the limits of vifion, as far as refpects luminous objects, may be afcertained by accurate obfervations of this kind.

Cambridge, 27th December, 1783.

XIV. *Obſervations of an Eclipſe of the Moon, March 29, 1782, and of an Eclipſe of the Sun, on the 12th of April following, at* Ipſwich, *Lat.* 42° 38′ 30″. *By the Reverend* MANASSEH CUTLER, *F. A. A.*

IN the following obſervations I made uſe of a reflecting teleſcope, made by *Mann*, magnifying 45 times. My clock was carefully regulated by taking correſponding double altitudes of the ſun, reflected from a bowl of the oil of tar, with *Hadley's* quadrant.

The night of 29th of March was exceedingly clear, and the atmoſphere very free from vapour. At 2h. 15′ 1″ apparent time, I obſerved a duſky appearance on the part of the moon's limb, which was then juſt within the lower part of the field of my teleſcope; and, bringing it inſtantly into the center of the field of view, found the penumbra conſiderably advanced, and in about 42″ perceived an impreſſion from the ſhadow.

Apparent Time.			
At 2h.	15′	1″	diſcovered the penumbra ſomewhat advanced.
2	15	42	eclipſe began.
2	21	17	in contact with *Gaſſeudus.*
2	25	37	in contact with *Mare Humorum.*
2	30	31	in contact with *Tycho.*
2	33	30	in contact with *Grimaldus.*
2	34	35	in contact with *Pitatus.*
2	40	11	*Grimaldus* covered.
2	54	55	in contact with *Snellius et Furnerius.*
3	2	1	in contact with *Keplerus.*
3	10	23	*Dionyſius* covered.
3	14	2	*Promontorium Acutum Cenſorinus* covered.

Apparent

Apparent Time.			
At 3^h	24′	13″	*Manilins* covered.
3	26	39	*Plinius* covered.
3	31	9	in contact with *Mare Crisium.*
3	40	20	*Grimaldus* begins to emerge.
3	53	54	emersion of *Manilins* and *Plinius.*
4	45	40	emersion of *Mare Nectaris.*
4	51	25	emersion of *Snellius et Furnerius.*
4	55	20	eclipse ends.
4	57	5	day-light so far advanced that the penumbra could no longer be perceived.

On the 12th of April I was favoured with the company of the Reverend Mr. *Prince*, of *Salem*, and Mr. *Brown Emerson*, of *Reading*, who observed the eclipse with me. Mr. *Prince* made use of a reflecting telescope, the magnifying power not known, but supposed to be about 45. Mr. *Emerson* observed with a reflector, made by *Mann*, magnifying 34 times.

The day was fine, and the sky unusually clear in the morning; but before twelve o'clock the sun was frequently covered with detached flying clouds. Just at the time the eclipse began, however, the sun was free from any cloud and excellently defined. I was so fortunate as to have the point in the sun's limb, where the contact took place, full in the field of view, and noted the second that was called when I first suspected an impression, though I was not certain of the contact for the space of two or three seconds after. Before the eclipse ended, the wind breezed up fresh, and the vapour increased so as to occasion a constant undulation of the sun's limb. We were, therefore, not so certain about the time of the ending, as we were of the beginning of the eclipse.

	Mr. *Prince*.	Mr. *Emerson*.	Myself.	
Beginning,	0h 12′ 52″	0h 12′ 48″	0h 12′ 46″	Apparent time.
End,	2 53 19	2 53 6	2 53 15	
Duration,	2 40 27	2 40 18	2 40 29	

The latitude of my house has been found, by the mean of about twenty double altitudes of the sun, when on the meridian, taken with an *Hadley's* quadrant, to be 42° 38′ 30″.

XV. *On the Extraction of Roots. By* BENJAMIN WEST, *Esquire, F. A. A. In a Letter to Mr.* CALEB GANNETT, *Rec. Sec. F. A. A.*

DEAR SIR,

HAVING a little leisure at this time, I thought it a proper opportunity to fulfil my promise of sending you the substance of what I have done, respecting the Roots. What I chiefly aimed at was, to render the method of extracting the roots of the odd powers easier, and less burthensome to the memory; and, I think, I have not failed in my attempt. The method, followed by *Ward* and others, is excellent, but is attended with too much difficulty in getting the divisors; especially for learners, who are not acquainted with the reason of the rules.—That difficulty I have strove to remedy in the following work. In the course of my teaching, since I made this discovery, I have not met with more trouble in teaching the third, fifth and seventh powers, than what is usual in extracting the square root. Methods, similar to these, may be found for extracting the roots of the even powers.

I generally get the three first figures in the root by the first operation, (if there are so many in the root) tho' many times four or five may be got, if the first figure in the root comes very near to the first period of the resolvend.

As it is not necessary to make a long introduction, I shall proceed to show in what manner I investigated the rules. The cube root being the first in order, I shall begin with that; and in order thereto, let the resolvend be $= a$; the first figure in the root $= r$; and the remaining figures in the root $= e$; and then

then the root will be $r+e$; and, by involution $r^3+3r^2e+3re^2+eee=a$. By dropping e^3, and making the other terms equal to a, we shall have $r^3+3re^2+3re=a$; and by subtraction $3re^2+3re^2=a-r^3$; and by division $e^2+re=\frac{a-r^3}{3r}$; and by compleating the square, we shall have $e^2+re+\frac{r^2}{4}=\frac{a-r^3}{3r}+\frac{r^2}{4}=\frac{4a-r^3}{12r}$; by extracting the square root of both sides, it will give $e+\frac{r}{2}=\sqrt{\frac{4a-r^3}{12r}}$; whence $e=-\frac{r}{2}+\sqrt{\frac{4a-r^3}{12r}}$; and by the addition of r on each side, it will be $r+e=r-\frac{r}{2}+\sqrt{\frac{4a-r^3}{12r}}=\frac{r}{2}+\sqrt{\frac{4a-r^3}{12r}}$. From which comes this rule:

Take the nearest root to the first period of the resolvend, be it more or less than just, and supply it with as many cyphers as there are remaining periods in the resolvend, and call it the assumed root. Then multiply the given resolvend by 4; from the product subtract the cube of the assumed root; divide the remainder by 12 times the assumed root, and extract the square root of the quotient. To the square root, thus found, add one half of the assumed root, and it will give the cube root corrected; which may be repeated and carried to what exactness you may wish to have it;—always taking the last root for the assumed root.

Take an example or two.—Let it be required to extract the cube root from 735051274. Here 9 is the nearest root 735, and 900 is the assumed root, less than just.

735051274

```
          735051274(900=assumed root.
                 ×4
          ----------
           3  2940205096
      900  = — 729000000
          ----------
900×12 = 108|00)22112050|96(204741
          216 · · · · ·
          ----
           512        4  )   204741(452,
           432        4       16      450=the assumed root.
           ----      --      ---      ---
            800       85      447     902=true root, nearly,
            756        5      425
            ---      ---     ----
             445      902     2241
             432              1804
             ---              ----
              130              437
              108
              ---
               22
```

Take a second example. Extract the cube root from 330625.

```
        330625(70=assumed root, more than just.
           ×4
        -------                              The work repeated,
   3    1322500
 70 = — 343000                                      69,1
        -------                                     69,1
70×12=84|0)97950|0  (  1166,07 (34,1                ----
      84 · · ·   3     9        35, = ½ 70           691
      ----       3     ---      ----------          6219
      139      ----    266      69, 1 corrected.   4146
       84       64     256                        -----------
      ----       4     ----                       4774,81 square.
      555      ----     1007                         69,1
      504      681       681                      -----------
      ----              ----                      2864886
       510               326                       429733
       504                                           4774
       ----                                       -----------
        600                                       329939,3 cube.
        588
        ---
         12
```

```
              3   1322500
        69, 1  = — 329939, 3
                 ——————————
69, 1x12=829, 2)992560, 7(1197, 010009647852
               : : 8292·· :
                   ————
                   16336          3 ) 1197,010009647852(34,597832
                    8292          3   9                  34,55=½69, 1
                   —————          —   ———               ——————————
                   80440          64  297               69,147832 root.
                   74628           4  256
                   —————          ——  ————
                    58127         685  4101
                    58044           5  3425
                    —————         ———  —————
                      8300        6909  67600
                      8292           9  62181
                      —————       ————  —————
                        80000     69187  541909
                        74628         7  484309
                        —————     —————  ——————
                         53720    691948  5760064
                         49752         8  5535584
                         —————    ——————  ———————
                          39680   6919563  22448078
                          33168         3  20758689
                          —————   ———————  ————————
                           65120  69195662  168938952
                           58044            138391324
                           —————            —————————
                            70760            30547628
                            66336
                            —————
                             4324
                             4146
                             ————
                              178
                              165
                              ———
                               13
```

Two examples being sufficient to illustrate the rule, I shall proceed to the surfolid, or fifth power. The investigation is as follows:

Let $a =$ the resolvend; $r =$ the first figure in the root, and $e =$ the remaining figures. Then $r + e =$ true root, and $r^5 + 5r^4e + 10r^3e^2 + 10r^2e^3 + 5re^4 + e^5 = a$; and by dropping all the terms that contain a higher power of e than e^2, and by

by making the remainder equal to a, there will be $r^5 + 5r^4e + 10r^3e^2 = a$, and then $5r^4e + 10r^3e^2 = a - r^5$; and by division $e^2 + \frac{1}{2}re = \frac{a-r^5}{10r^3}$; and by compleating the square we shall have $e^2 + \frac{1}{2}re + \frac{r^2}{16} = \frac{a-r^5}{10r^3} + \frac{r^2}{16} = \frac{16a-6r^5}{160r^3} = \frac{8a-3r^5}{80r^3}$*; and by extracting the square root, $e + \frac{r}{4} = \sqrt{\frac{8a-3r^5}{80r^3}}$; and by subtraction $e = -\frac{r}{4} + \sqrt{\frac{8a-3r^5}{80r^3}}$; and by adding r on both sides; $r + e = r - \frac{r}{4} + \sqrt{\frac{8a-3r^5}{80r^3}} = \frac{3}{4}r + \sqrt{\frac{8a-3r^5}{80r^3}}$. Whence this rule:

Take the nearest root to the first period of the resolvend, more or less than just, and annex as many cyphers, as there are remaining periods in the resolvend, and call it the assumed root. Multiply the resolvend by 8, and from the product take 3 times the fifth power of the assumed root; divide the remainder by 80 times the third power of the assumed root, and extract the square root of the quotient; to which add three fourths of the assumed root, and it will give the sursolid root corrected:—It may be repeated, and carried to what exactness you would have it; still taking the last root from the assumed root.

Let us take an example from *Ward*: Extract the sursolid root from 123095020069375. Here the nearest sursolid root to 1230 is 4, and the assumed root 400, less than just.

X 123095020069375

* The co-efficients are divided by their greatest common measure. *Euc.* b. 7. p. 3.

```
                         12309502009375 (400=aſſumed root.
                                    x8
                         ——————————————
                 5       98476016075000
             400x3 = —   30720000000000
          3              ——————————————
400x80=512 0000000)6775601|6075000 (  13233 ( 115
                         512                  1     300
                         ———          1       —     ———
                         1655         1      32     415 = root.
                         1536         —      21
                         ————        21      ————
                          1196        1     1133
                          1024        ——    1125
                          ————      225     ————
                           1720                8
                           1536
                           ————
                            1841
                            1536
                            ————
                             305
```

One caſe being ſufficient to exemplify the rule, I ſhall not trouble you with a ſecond. The next is the ſecond ſurſolid, or ſeventh power: And let the ſame letters ſtand for the ſame things, as in the preceding powers; and then we ſhall have $r^7 + 7r^6e + 21r^5e^2 + 35r^4e^3 + 35r^3e^4 + 21r^2e^5 + 7re^6 + e^7 = a$; and by neglecting all the terms that contain a greater power of e than e^2, and making the remainder equal to a, there will ariſe $r^7 + 7r^6e + 21r^5e^2 = a$; and $7r^6e + 21r^5e^2 = a - r^7$; and by diviſion $e^2 + \frac{1}{3}re = \frac{a-r^7}{21r^5}$; and by compleating the ſquare, $e^2 + \frac{1}{3}re + \frac{r^2}{36} = \frac{a-r^7}{21r^5} + \frac{r^2}{36} = \frac{12a-5r^7}{252r^5}$:* By extracting the ſquare root of both ſides of the equation, there will ariſe $e + \frac{1}{6}r = \sqrt{\frac{12a-5r^7}{252r^5}}$; and $e = -\frac{1}{6}r + \sqrt{\frac{12a-5r^7}{252r^5}}$. And furthermore, if r be added to both ſides of the equation, there will be had, $r + e = r - \frac{1}{6}r + \sqrt{\frac{12a-5r^7}{252r^5}} = \frac{5}{6}r + \sqrt{\frac{12a-5r^7}{252r^5}}$. Whence this rule:

Take

* See note, p. 166.

Take the nearest second sursolid root to the first period of the resolvend, and place as many cyphers at it's right hand as there are remaining periods in the resolvend, and call it the assumed root. Multiply the resolvend by 12, and take 5 times the seventh power of the assumed root from the product, and divide the remainder by 252 times the fifth power of the assumed root; extract the square root of the quotient, and add the root to $\frac{5}{6}$ of the assumed root, and it will give the second sursolid root corrected; which may be repeated and carried to the desired accuracy,—remembering to take, in each operation, the last root for the assumed root. We will take *Ward's* example, viz. Extract the second sursolid root from 382986553955078125. Here the nearest root to 3829, is 3, and 300 is the assumed root, less than just.

```
                              382986553955078125(300
                                                ×12
                              ---------------------
                    7         4595838647460937500
              300×5 = —       10350000000000000000
                              ---------------------
   5
300×252=61236,0000000000)3502338647460937500(5719
                              306180
                              ------
                               440538
                               428652
                               ------
                               118866
                                61236
                               ------
                               576304
                               541124
                               ------
                                35180

        ..
  7  )  5719  (  75
  7     49       250 = 5/6 of the assumed root.
 ---    ---      ---
 145    819      325 = root, agreeable to Ward.
        725
        ---
         94
```


SCHOLIUM.

SCHOLIUM.

It may be obſerved, that in the foregoing examples, I have carried the work out at large: This I did in order to avoid any ſeeming embarraſſments. Whatever contractions are made uſe of by *Ward*, or others, may be adopted, with equal propriety, in theſe methods; and I have not met with an inſtance, in which theſe rules do not approach the root with equal celerity, as thoſe of the forementioned author.

I am, &c.

BENJAMIN WEST.

To Mr. *Caleb Gannett*.

XVI. *A new and concise Method of computing Interest at Six per Cent. per Annum.* By PHILOMATH.

LET the intereſt of £.745 be required for 16 months at 6 per cent. per annum.

Operation at large.—According to the double Rule of Three, or (as it is ſometimes called) the Rule of Five, the queſtion will be ſtated thus:

If £.100 in 12 months gain £.6, what will £.745 gain in 16 months?

For ſolution.—Of theſe five terms ſo ranged,

```
 £.     m.    £.     £.     m.
100 :  12  :  6  :  745  :  16,
```

the three laſt are to be multiplied together, for a dividend; and the two firſt for a diviſion: And the quotient will be the anſwer to the queſtion. Thus,

```
                    745
                     16
                   ----
                   4470
 100                745
  12              -----
----              11920
 200                  6
100               -----
----              71520 ( £.59
1200   )          6000
                  -----
                  11520
                  10800
                  -----
          Remain.  720
                    20
                  -----
                )14400 ( 12s.
                 1200
                  -----
                  2400
                  2400
                  ------
        Answer, £.59 12 0
```

If the dividend and divisor, in the foregoing operation, be lessened in the same proportion, or, like parts, be taken instead of their wholes, as, if one sixth part of the former dividend be divided by one sixth part of the former divisor, the quotient and answer will be the same as before. But the product of the two last terms in the stating (omitting the multiplication by the third term 6) is equal to one sixth of said dividend :— Therefore, if the product of said two last terms be divided by 200, equal to one sixth of the former divisor, the quotient and answer will be as before. Thus,

```
                 745
                  16
                ----
                4470
                 745
               -----
         200 ) 11920 (£.59
               1000
               -----
                1920
                1800
               -----
     Remain.     120
                  20
               -----
                2400 ( 12s.
                 200
               -----
                 400
                 400
```

If instead of the dividend 11920, in the last operation, being divided by 200, it be divided by one of the two numbers, *e. g.* 10 and 20, the rectangle whereof is equal to 200, the divisor there, and the quotient thence arising be divided by the other of said two numbers, the last quotient and answer will be the same as before. Thus,

10

```
10)11920 ( 1192
   10
   ---
    19
    10        20)1192(£.59
    ---           100
     92           ---
     90           192
     --           180
      20          ---
      20          12s.
```

Note here.—The firſt quotient is ſhillings, it taking 20 of them in the ſecond diviſion to make a pound; and the remainder, after the firſt diviſion, (if any) expreſſes tenths of a ſhillings.

Again.—Inſtead of the former dividend, 11920, being divided by 200, if one half ſaid dividend, or, half the product of the two laſt terms of the ſtate of the queſtion, (which is equal to the product of either of the ſaid two laſt terms multiplied into half the other) be divided by half the ſaid diviſor 200, = 100, there will be the ſame quotient and anſwer as before. Thus,

```
200      11920
---      -----
100  )   5960(£.59
         500
         ---
          960
          900
          ---
Remain.    60
           20
          ---
         1200 ( 12s.
         100
         ---
          200
          200
```

From the premiſes reſult the following rules for computing intereſt at 6 per cent. per annum, in a *new concise method*, made

uſe of by many gentlemen, but which is not commonly known.

1. If any ſum of money be multiplied by the number of months and parts of a month it is at intereſt, at the rate of 6 per cent. per annum, and the right-hand figure of the pounds in the product be ſeparated by a comma from the others, (if any be) thoſe other figures will be the ſhillings which the intereſt doth come to for the time given, and the right-hand figure, ſeparated as aforeſaid, will be the decimal, that is, the tenth part of a ſhilling.

Example. What is the intereſt of £.745, for 16 months, at 6 per cent. per annum?

Operation.

	£.745
	16
	4470
	745
20s.	119, 2, 0
Anſ.	59, 12, 0

2. If any ſum of money be multiplied by one half of the time in months and parts of a month it is at intereſt, at 6 per cent. per annum, and the two right-hand figures of the pounds in the product be ſeparated with a comma from the others, (if there be any) thoſe other figures, if any there be, will be the pounds that the intereſt doth come to for the time given; and the right-hand figure, ſo ſeparated, will be the decimal parts of a pound.

Example. What is the intereſt of £.745, for 16 months, at 6 per cent. per annum?

Operation.

Operation.

£.745
8
59,60
20
12,00
Anſ. £.59 12

If under either of theſe rules, in the product, there be no figures in the place of pounds, ſupply them by one or two cyphers. If under the ſecond rule, there be but one figure in the place of pounds, ſupply by prefixing one or two cyphers.*

The multiplication of pounds, ſhillings, pence, &c. by months and ſuch number of days as are not an exact half, third part, &c. of a month, may indeed ſometimes prove burthenſome to the mind.

But by the help of the two ſubſequent tables of decimals, one of the parts of a pound, and the other of the parts of a month, the intereſt of any ſum of money, conſiſting of divers denominations of pounds, ſhillings, pence, and even farthings, for any given number of months and days, may, upon the principles on which the ſecond rule aforegoing is founded, by an eaſy proceſs and with ſufficient accuracy, be computed.

Y A

* In both theſe rules, the ſum at intereſt is ſuppoſed to be given in pounds, &c. But if the ſum at intereſt be given in dollars, the intereſt thereon may be computed by the ſecond rule ; only obſerving, that the figures in the product, (of the ſum by half the time) on the left hand of the comma, will be dollars, and thoſe on the right hand will be the decimal parts of a dollar.

A Table of Decimal Parts of a Pound, or twenty Shillings.

s.	*d.*	*q.*		*s.*	*d.*		*s.*	*d.*		*s.*	*d.*		*l.*	*s.*	*d.*	
0	0	1	0010	3	11	1959	8	0	4000	12	1	6042	0	16	2	8084
	0	2	0021	4	0	2000	8	1	4042	12	2	6084		16	3	8125
	0	3	0031	4	1	2042	8	2	4084	12	3	6125		16	4	8167
	1	0	0042	4	2	2084	8	3	4125	12	4	6167		16	5	8209
	2	0	0084	4	3	2125	8	4	4167	12	5	6209		16	6	8250
	3	0	0125	4	4	2167	8	5	4209	12	6	6250		16	7	8292
	4	0	0167	4	5	2209	8	6	4250	12	7	6292		16	8	8334
	5	0	0209	4	6	2250	8	7	4292	12	8	6334		16	9	8375
	6	0	0250	4	7	2292	8	8	4334	12	9	6375		16	10	8417
	7	0	0292	4	8	2334	8	9	4375	12	10	6417		16	11	8459
	8	0	0334	4	9	2375	8	10	4417	12	11	6459		17	0	8500
	9	0	0375	4	10	2417	8	11	4459	13	0	6500		17	1	8542
	10	0	0417	4	11	2459	9	0	4500	13	1	6542		17	2	8584
	11	0	0459	5	0	2500	9	1	4542	13	2	6584		17	3	8625
1	0	0	0500	5	1	2542	9	2	4584	13	3	6625		17	4	8667
1	1	0	0542	5	2	2584	9	3	4625	13	4	6667		17	5	8709
1	2	0	0584	5	3	2625	9	4	4667	13	5	6709		17	6	8750
1	3	0	0625	5	4	2667	9	5	4709	13	6	6750		17	7	8792
1	4	0	0667	5	5	2709	9	6	4750	13	7	6792		17	8	8834
1	5	0	0709	5	6	2750	9	7	4792	13	8	6834		17	9	8875
1	6	0	0750	5	7	2792	9	8	4834	13	9	6875		17	10	8917
1	7	0	0792	5	8	2834	9	9	4875	13	10	6917		17	11	8959
1	8	0	0834	5	9	2875	9	10	4917	13	11	6959		18	0	9000
1	9	0	0875	5	10	2917	9	11	4959	14	0	7000		18	1	9042
1	10	0	0917	5	11	2959	10	0	5000	14	1	7042		18	2	9084
1	11	0	0959	6	0	3000	10	1	5042	14	2	7084		18	3	9125
2	0	0	1000	6	1	3042	10	2	5084	14	3	7125		18	4	9167
2	1	0	1042	6	2	3084	10	3	5125	14	4	7167		18	5	9209
2	2	0	1084	6	3	3125	10	4	5167	14	5	7209		18	6	9250
2	3	0	1125	6	4	3167	10	5	5209	14	6	7250		18	7	9292
2	4	0	1167	6	5	3209	10	6	5250	14	7	7292		18	8	9334
2	5	0	1209	6	6	3250	10	7	5292	14	8	7334		18	9	9375
2	6	0	1250	6	7	3292	10	8	5334	14	9	7375		18	10	9417
2	7	0	1292	6	8	3334	10	9	5375	14	10	7417		18	11	9449
2	8	0	1334	6	9	3375	10	10	5417	14	11	7459		19	0	9500
2	9	0	1375	6	10	3417	10	11	5459	15	0	7500		19	1	9542
2	10	0	1417	6	11	3459	11	0	5500	15	1	7542		19	2	9584
2	11	0	1459	7	0	3500	11	1	5542	15	2	7584		19	3	9625
3	0	0	1500	7	1	3542	11	2	5584	15	3	7625		19	4	9667
3	1	0	1542	7	2	3584	11	3	5625	15	4	7667		19	5	9709
3	2	0	1584	7	3	3625	11	4	5667	15	5	7709		19	6	9750
3	3	0	1625	7	4	3667	11	5	5709	15	6	7750		19	7	9792
3	4	0	1667	7	5	3709	11	6	5750	15	7	7792		19	8	9834
3	5	0	1709	7	6	3750	11	7	5792	15	8	7834		19	9	9875
3	6	0	1750	7	7	3792	11	8	5834	15	9	7875		19	10	9917
3	7	0	1792	7	8	3834	11	9	5875	15	10	7917		19	11	9959
3	8	0	1834	7	9	3875	11	10	5917	15	11	7959	1	0	0	10000
3	9	0	1875	7	10	3917	11	11	5959	16	0	8000				
3	10	0	1917	7	11	3959	12	0	6000	16	1	8042				

A Table of Decimal Parts of a Month.

Days.		D.		D.		D.		M.D.	
1	0333	7	2333	13	4333	19	6333	25	8333
2	0667	8	2667	14	4667	20	6667	26	8667
3	1000	9	3000	15	5000	21	7000	27	9000
4	1333	10	3333	16	5333	22	7333	28	9333
5	1667	11	3667	17	5667	23	7667	29	9667
6	2000	12	4000	18	6000	24	8000	1 0	1,0000

When intereſt at the rate of 6 per cent. per annum, is to be computed on any given ſum of money and for any given time, and the money or time, or both, be of divers denominations, ſet down the money at intereſt in pounds and decimal parts of a pound, and the time in months and decimal parts of a month, (the decimals being taken from the tables reſpectively) and multiply the whole of one of them by half of the other, and count off two more of the right-hand figures of the product than there are places of decimals in the multiplicand and multiplier together, and there place a comma, to ſeparate them from the other figures of the product, if any be; but if there be not ſo many figures in the product, ſupply them by prefixing cyphers; and then the figures (if there be any) on the left hand of the comma, will be the pounds that the intereſt comes to for the given time; and the figures on the right hand of the comma will be decimal parts of a pound,—three or four of which, next the comma, may be ſufficient in common caſes to retain, and the reſt may be expunged.

Example. Let the intereſt of £.745 15s. 6d. for 1 year 7 months and 11 days, at 6 per cent. per annum, be computed.

Money.	M. Time.
£.745, 775	2)19, 3667
9, 6833	9, 6833
2237325	
2237325	
5966200	
4474650	
6711975	
72,2156	
20	
4,3120	
12	
3,6440	
4	
2,5760	

Anſ. £.72. 4s. 3d. 2q.

This method is adapted to reckoning intereſt at the rate of 6 per cent.—But from the intereſt at 6 per cent. the intereſt at any other given rate may be obtained, as follows:

One *ſixth* part of the intereſt at 6 per cent. is the intereſt at 1 per cent.—One *third* is the intereſt at 2 per cent.—One *half* is the intereſt at 3 per cent. If from the intereſt at 6 per cent. there be ſubtracted one *third* of it, the remainder will be the intereſt at 4 per cent.—If one *ſixth* be ſubtracted, the remainder will be the intereſt at 5 per cent.

Again.—If to the intereſt at 6 per cent. there be added one *ſixth* part thereof, the ſum will be the intereſt at 7 per cent.—If there be added one *third*, the ſum will be the intereſt at 8 per cent.—If there be added *half*, the ſum will be the intereſt at 9 per cent.—If two *thirds*, the ſum will be the intereſt at 10 per cent.—If one *half* and one *third*, the ſum will be the intereſt at 11 per cent.—The double of the intereſt at 6 per cent.

cent. is the intereſt at 12 per cent.—If to that double there be added one ſixth of the intereſt at 6 per cent. the ſum will be the intereſt at 13 per cent. &c.

And this diviſion, addition or ſubtraction may be made immediately after the firſt operation of multiplying the money at intereſt by half the time, or *è contra*, and before the ſeparating the figures into pounds and decimals.

Example. Let there be computed the intereſt of £.480, for 7 months and 15 days, at 5 per cent. per annum.

```
£.480,        M.
   3,75      7,50
 -------     -----
   2400      3,75
  3360
 1440
 -------
 180000 at 6 per cent.
  30000 1/6 deduct.
 -------
 15,0000 at 5 per cent.
     Anſ. £.15.
```

Example. Let the intereſt of £.345 15s. for 9 months and 6 days, be computed, at the rate of 7 per cent. per annum.

```
£.345,75       9,20
     4,60      -----
 ---------     4,60  half the time.
  2074500
 138300
 ---------
 15904500 at 6 per cent.
  2650750 1/6 add.
 ---------
 18,565250 at 7 per cent.
        20
 ----------
 11,305000
        12
 ----------
  3,660000
         4
 ----------
  2,640000
   Anſ. £.18 11s. 3d. 2q.
```

Let

Let it be obſerved here,—in this proceſs as well as others, where there are decimals of a pound to be valued, there is no need of the ſeveral multiplications by 20, 12 and 4 for that purpoſe: But the preceding table of decimal parts of a pound being calculated to four places, if we repair to that with ſo many of the decimals (next the comma) to be valued, we ſhall there find their value, by inſpection.

May 15, 1781.

XVII. *Several Ways of determining what Sum is to be insured on an Adventure, that the whole Interest may be covered.* *By* MERCATOR.

1. THE first and most common way is, to cast the premium of insurance at the stipulated rate, on the adventure,—on that premium,—on the premium of the first premium, and so on until the premium be so small as not to be worth noticing; then to collect the adventure and these several premiums (first and secondary) into one sum, which will be the sum to be insured.

Example. Adventure, £.315;—rate of insurance, 30 per cent.

```
£.315
   30
-----
 94,50
    20
------
 10,00
```

First premium.

```
£.94. 10. 0
         10
-----------
  945. 0. 0
          3
-----------
28,35. 0. 0
   20
   --
 7,00
```

Second premium.

```
£.28.  7. 0
          10
------------
283. 10.  0
          3
------------
8,50. 10. 0
      20
     -----
     10,10
        12
      ----
      1,20
         4
      ----
       ,80
```

Third premium.

```
£.8. 10. 1 1/4
            3
--------------
25. 10. 3, 3
          10
--------------
2,55. 3. 1. 2
  20
-----
11,03
   12
  ---
  ,37
    4
   --
 1,50
```

Fourth

Fourth premium.

£.2. 11. 0. 2
10
25. 10. 5. 0
3
,76. 11. 3. 0
20
15,31
12
3,75
4
3,00

Sixth premium.

£.0. 4. 7. 1
3
0. 13. 9. 3
10
,06. 18. 1. 2
20
1,38
12
4,57
4
2,30

Eighth premium.

£.0. 0. 5. 0
30
0. 12. 6. 0
12
1,50
4
2,00

Ninth premium.

£.0. 0. 1. 2
30
1. 3. 0
2. 6.
3. 9. 0
12
,45
4
1,80

Fifth premium.

£.0. 15. 3. 3
10
7. 13. 1. 2
3
,22. 19. 4. 2
20
4,59
12
7,12
4
,50

Seventh premium.

£.0. 1. 4. 2
30
,1. 3. 0
10
1. 10
,02. 1. 3. 0
20
,041
12
4,95

Tenth premium.

2 farthings.

Collection.

Adventure,	£.315.	0.	0.	0
1st. premium,	94.	10.	0.	0
2d.	28.	7.	0.	0
3d.	8.	10.	1.	1
4th.	2.	11.	0.	2
5th.		15.	3.	3
6th.		4.	7.	1
7th.		1.	4.	2
8th.		0.	5.	0
9th.		0.	1.	2
10th.			0.	2
	450.	0.	0.	1

And

And obſerve :—The greater the rate of inſurance, the more operations are requiſite ; becauſe the leſs of the adventure will be covered by the inſurance of each preceding premium.

2. Another way.—Caſt the premium of inſurance on the adventure, (as before) which, ſubtract from the adventure ;—then, by the Rule of Three, it will be—as that remainder : the adventure :: the adventure : the ſum to be inſured.

Example. Adventure, £.315.—Rate of inſurance, 30 per cent.

```
£.315          £.315.  0. 0        As £.220. 10s. : £.315 :: £.315 :
   30              94. 10. 0                  20                    20
 -----          -------------                ----                 ----
 94,50     Remain. 220. 10. 0               4410                  6300
    20                                                             315
 -----                                                            ----
 10,00                                                           31500
                                                                  6300
                                                                 18900
                                                              ---------
                                                       4410) 1984500(450
                                                              17640
                                                              -----
                                                              22050
                                                              22050
                                                              ------
                                                              000000
```

The laſt operation here is beſt done, in many caſes, by decimal arithmetick : Thus,

```
      As 220,5 : 315 :: 315
                        315
                      -----
                      99225

220,5 ) 99225,0 ( 450
         8820
        -----
        11025
        11025
        ------
        000000
```

3. Another and very expeditious way is as follows:

Multiply the adventure by 100; and divide the product by 100 less the rate of insurance, (or, the difference between 100 and the rate of insurance) and the quotient will shew the sum to be insured.

Example. Adventure, £.315. Rate of insurance 30 per cent.

100 315
30 100
70) 31500 (450
280..
0350
350
0000

PART II.

PHYSICAL PAPERS.

I. *Observations upon an Hypothesis for solving the Phenomena of Light: with incidental Observations, tending to shew the Heterogeneousness of Light, and of the electric Fluid, by their Intermixture, or Union, with each other.*

By JAMES BOWDOIN, *Esquire,*
President of the American *Academy of Arts and Sciences.*

IN reviewing some letters I had written to a philosophical friend, Dr. *Franklin*, there occurred on the subject of one of them some observations, which appeared to me new. They are principally contained in the two last of three memoirs, which I shall lay before the Academy: to whose judgment it will be submitted, whether they have any thing beside their novelty to recommend them.

As they were occasioned by considering Dr. *Franklin's* queries concerning light, the strictures on those queries, as being introductory to the observations, will make a part of these memoirs.

The first memoir will accordingly contain a few strictures, or cursory remarks, on his hypothesis for solving the phenomena of light: with incidental observations concerning the hetorogeneousness of light, and the electric fluid.

It is offered in full confidence, that our celebrated countryman, whoſe happy genius has contributed ſo largely to the advancement of philoſophic knowledge, will be pleaſed with any attempt for that purpoſe, whether ſucceſsful or not, even though it ſhould be upon principles, that may not perfectly harmonize with ſome of his own.

The Doctor, diſſatisfied with the received doctrine concerning light, offers ſeveral objections to it in the form of queries; and in the ſame form propoſes an hypotheſis of his own: both of which will be conſidered.

With reſpect to the hypotheſis, it is aſked— * "May not all the phenomena of light be more conveniently ſolved, by ſuppoſing univerſal ſpace filled with a ſubtle elaſtic fluid, which, when at reſt, is not viſible, but whoſe vibrations affect that fine ſenſe in the eye, as thoſe of air do the groſſer organs of the ear? We do not, in the caſe of ſound, imagine that any ſonorous particles are thrown off from a bell, for inſtance, and fly in ſtraight lines to the ear: why muſt we believe that luminous particles leave the ſun, and proceed to the eye? Some diamonds, if rubbed, ſhine in the dark, without loſing any part of their matter. I can make an electrical ſpark as big as the flame of a candle, much brighter, and therefore viſible further; yet this is without fuel: and I am perſuaded no part of the electric fluid flies off in ſuch caſe to diſtant places, but all goes directly, and is to be found in the place to which I deſtine it.—May not different degrees of the vibration of the abovementioned univerſal medium, occaſion the appearances of different colours? I think the electric fluid is always the ſame; yet

* See Letters and Papers on Philoſophical Subjects. p. 265. edit. 1769.

yet I find that weaker and ſtronger ſparks differ in apparent colour : Some white, blue, purple, red ;—the ſtrongeſt, white ; weak ones, red."

Several objections here preſent themſelves. Some of them ariſing from the hypotheſis itſelf ; and others from the compariſon of light with ſound.

In reſpect of the former, if univerſal ſpace be filled with a ſubtle elaſtic fluid, (ſo as to exclude any vacuum) that fluid muſt always be at reſt, and therefore by the hypotheſis always inviſible ; and conſequently there would always be univerſal darkneſs. Or if any part of the fluid could be put in motion, the whole of it muſt be in motion : for not one particle of it could move, without moving, in the direction of its motion, the adjoining one, and this the next ; and ſo on, *ad infinitum.* In this caſe, the leaſt motion, wherever it might commence, muſt produce univerſal motion ; and conſequently, univerſal light : between which, and univerſal darkneſs, there could be no medium.

But if the meaning of the expreſſion be, what it was probably intended to be, that univerſal ſpace, inſtead of being filled, doth greatly abound, with an elaſtic fluid, then would not every thing, which diſturbed that fluid, cauſe a luminous appearance ? Would not the inhabitants of the ſea and air, in all their motions, beſpangle both ; and thereby exhibit the various colours according to the different degrees of vibration, which thoſe motions might occaſion in the elaſtic fluid ?—As to ourſelves, would not a radiance attend us wherever we went ? What occaſion ſhould we have of candle-light, when a quick vibration of the hand, or of machines made for that purpoſe, would diſpel the night ? Or rather, might we not ſuppoſe there

there would be no night at all? for the action of the sun (if the sun should be necessary) would be communicated to us, notwithstanding the interposition of the earth. And would not the effect of that action, even at noon when most direct, be only to enlighten us, unattended with heat, so essentially necessary to enliven and invigorate the animal and vegetable world?—Would not the elastic fluid, instead of exhibiting a round luminous body, which we call the sun, be itself a continued universal blaze of light? And would not this, in the present constitution of things, obstruct vision, and totally alter the science of optics?

The objections, implied in the foregoing queries, seem deducible from the hypothesis. There are several, which appear to arise from the comparison of light with sound.

1° As sound (or a vibrating, or undulating, motion in the air, which I consider here as synonimous) is propagated from the sonorous body in all directions; and surrounds, and is propagated beyond or behind any obstacle in its way: so light, if it was a vibration, or undulation, of the elastic fluid, would surround, and be propagated behind an obstacle, like sound: but this does not agree with the fact.—2° As sound, or the vibrating motion in the air, originating in a house or any other inclosure, would, from a hole in one of the sides of it, be propagated externally, in circles, of which the hole would be the centre: so light, if it was a vibration, or occasioned by a vibration, of the elastic fluid, after passing through a hole, would be propagated in circles, of which the hole would be the centre. But this does not correspond to the fact: for light, in passing through any uniform medium, always passes in right lines.

Beside

Beside these, an objection similar to one of those, which have been advanced against the common hypothesis, and which may be seen in the proper place, may be alledged against this : for the constant vibration, with which the elastic fluid must be agitated, would communicate to small bodies, and even to large ones suspended in that fluid, a constant tremulous vibratory motion. In such a case it would be difficult to examine the texture and visible qualities of those small bodies, as one necessary mean of examination, a great deal of light, would encrease the vibration ; and thereby render the examination not only difficult but impracticable. It is apprehended, however, that no such motion, or embarrassment, in the making of such examinations, has ever been observed.

What is mentioned about the electrical spark, that it is bright, and visible at a distance, and this without fuel ; and that no part of the electrical fluid flies off, in such case, to distant places, but all goes directly, and is to be found in the place, to which it is destined, appears to favour the hypothesis ; as the implied inference seems to be, that the visibility of the electric spark arises from the vibration it produces in the universal elastic fluid. But if the foregoing queries furnish sufficient reason for doubting the existence of such a fluid, or for doubting such an effect from it, supposing its existence, will they not furnish equal reason for doubting the hypothesis ?

The visibility of the electric spark may be accounted for, upon the principles of the received doctrine concerning light, without supposing any diminution of the pure electric fluid in the spark : no part of which, it is said, flies off in the case mentioned.

It

It ſeems not improbable, that the electric fluid is heterogeneous as well as light.

The heterogeneouſneſs of light is inferred from its colours, which are ſaid to vary proportionably, as the ſize of the particles doth vary: the variation becoming conſpicuous by a priſm, and by other means, which claſs the particles according to their reſpective magnitudes, or degrees of refrangibility, and reflexibility.

Beſide this, another reaſon may be ſuggeſted, from which the heterogeneouſneſs of light may be deduced: namely, becauſe it exhibits effects ſimilar to ſome of thoſe of electricity. For example, a globe or pane of glaſs warmed in the ſun or before a fire, will ſucceſſively attract and repel ſmall cork balls, down, and ſuch like bodies inſulated, and properly circumſtanced; and will ſhew other ſigns of electricity communicated to the glaſs by the ſun or fire.

So, in regard to electricity, its heterogeneouſneſs may be collected from its producing effects reſembling ſome of thoſe of light or fire; which are here conſidered as equivalent terms.

Electricity and fire differ in many reſpects, and in ſome they agree; as hath been ſhewn in Dr. *Franklin's* letters on electricity. So far as they agree in their effects, their nature may be preſumed to be alike: Or rather, from that agreement and ſimilitude of effects, I think it may be inferred, that they are mixt with, and generally do accompany each other; and that each produces its own effect at the time of their joint operation. The effects of electricity, ſimilar to thoſe of fire, being produced by the fire mixt with it; and the effects of fire, reſembling thoſe of electricity, being produced by the electricity mixt with that: the compound taking its name from the predominant principle.

Thus,

Thus, fire inflames bodies, and throws its particles or light at a diſtance. Hence, the exploſion of gun-powder, and the luminous appearance, occaſioned by the electric ſpark : the fire mixt with it producing thoſe effects.

Thus alſo, electricity attracts and repels certain ſmall bodies alternately, under given circumſtances. Hence, the alternate attraction and repulſion of glaſs, and ſome other things, heated by fire : the electricity mixt with the communicated fire producing thoſe effects.

In this way I would infer the heterogeneouſneſs of light and electricity, and their mixture with each other ; and in this way account for the ſimilitude and difference of their effects ; and for the luminous appearance or viſibility of the electric ſpark in particular, without diminiſhing the pure electric fluid contained in it : all of which, in the caſe referred to, is ſaid to go directly, and is to be found in the place, to which it was deſtined.

On the ſame principles the ſhining of diamonds in the dark when rubbed, and thereby electrified, may be accounted for, without ſuppoſing they looſe any part of their matter.

In regard to the different colours of the electric ſpark, which are more or leſs ſtrong according to the ſtrength of the ſpark, they correſpond to the different colours of light or fire, which are more or leſs vivid according to the denſity or intenſeneſs of that element. This ſameneſs of effect ſhews a ſameneſs of cauſe, or that the light or fire mixt with the electric ſpark produces thoſe colours : whoſe ſtrength or vividneſs being according to the bigneſs of the ſpark, or to its quantity of electric fluid, makes it probable, that in proportion to the quantity, there is more or leſs light or fire contained in that fluid.

Theſe different appearances ſeem to be a further inſtance or proof of the heterogeneouſneſs of the electric fluid ; and, taken in connection with other appearances above-mentioned, ſhew the intermixture, and the conſequent heterogeneouſneſs, of the two elements.

The next thing to be conſidered is, the objections to the received doctrine concerning light.—But this will be the ſubject of another memoir.

II. *Observations on Light, and the Waste of Matter in the Sun and fixt Stars, occasioned by the constant Efflux of Light from them: with a Conjecture, proposed by Way of Query, and suggesting a Mean, by which their several Systems might be preserved from the Disorder and final Ruin, to which they seem liable by that Waste of Matter, and by the Law of Gravitation.*

By JAMES BOWDOIN, *Esquire,*
President of the American *Academy of Arts and Sciences.*

HAVING in a preceding memoir laid before the Academy the observations, that occurred on the subject of Dr. *Franklin's* hypothesis relative to light, I shall now consider his objections to the received doctrine concerning it.

The objections will appear by the following paragraph taken from one of his letters on philosophical subjects.

" I must own, says the Doctor,* I am much in the dark about light. I am not satisfied with the doctrine, that supposes particles of matter called light, continually driven off from the sun's surface, with a swiftness so prodigious! Must not the smallest particle conceivable have, with such a motion, a force exceeding that of a twenty-four pounder, discharged from a cannon?

A a 2 [illegible] non ?

* See Letters and Papers on Philosophical Subjects. p. 264. edit. 1769.

Just as these memoirs were going to the press, an ingenious gentleman of the *American* Academy, favoured me with the Philosophical Transactions for 1770, (the 60th vol.) in which the Rev. Dr. *Horsley*, in a paper entitled, " Difficulties in the *Newtonian* Theory of Light, considered and removed," quotes this passage from Dr. *Franklin's* letters; and very ingeniously discusses the questions contained in it.

The subject being considered in that paper, upon principles different from those adopted in this memoir, there will not be found any similitude between them.

non ? Muſt not the ſun diminiſh exceedingly by ſuch a waſte of matter ? and the planets, inſtead of drawing nearer to him, as ſome have feared, recede to greater diſtances through the leſſened attraction ? Yet theſe particles, with this amazing motion, will not drive before them, or remove, the leaſt and lighteſt duſt they meet with : and the ſun, for aught we know, continues of his ancient dimenſions ; and his attendants move in their ancient orbits."

The Doctor's diſſatisfaction with the received doctrine, is founded on two objections implied in his queries, and which may be expreſſed in the following propoſitions.

1°· That, ſuppoſing the doctrine true, the ſmalleſt particle of light muſt be driven to us with prodigious force, a force exceeding that of a twenty-four pounder, diſcharged from a cannon. But this is contrary to fact.

2°· That the ſun muſt be exceedingly diminiſhed by ſuch a waſte of matter ; and the planets, in conſequence of it, muſt recede to greater diſtances from him. But, for aught we know, both the ſun and the planets, continue in their ancient ſtate.

From theſe propoſitions it is implicitly inferred, that the doctrine is not well founded.

Among the obſervations on the ſecond propoſition, an hypotheſis will be propoſed, by way of query, ſuggeſting a mean, whereby the material ſyſtem, collectively taken, might be preſerved from the diſorder and ruin, to which they ſeem liable from cauſes hinted at in that propoſition.

In regard to the objection contained in the firſt propoſition, it adopts the idea, that light, like any other body in motion, will ſtrike with a force proportioned to the degree of its motion : which degree of motion, or the celerity, multiplied by

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the quantity of matter in the body, will, in the reſult, expreſs its force or momentum.

If, then, we can ſuppoſe the quantity of matter in a particle of light to be, not indeed abſolutely, but comparatively, o, its momentum will alſo be comparatively o; and it can have, in that caſe, no viſible effect on the ſmalleſt particle of duſt to remove it.

Let us now conſider what reaſon there is for ſuch a ſuppoſition. In order to that, I beg leave to introduce here, a paragraph from one of my letters to Dr. *Franklin*, printed with his letters and papers on philoſophical ſubjects. It runs thus,* "The flame of a candle, it is ſaid, may be ſeen four miles round. The light, diffuſed through this circle of eight miles diameter, was contained, before it left the candle, within a circle of half an inch diameter. If the denſity of light, in theſe circumſtances, be as thoſe circles to each other, that is, as the ſquares of their diameters (or, which is equivalent, if the denſity decreaſes as the ſquare of the diſtance or ſemi-diameter increaſes) the candle-light, when come to the eye, will be 1027,709,337,600 times rarer than when it firſt quitted the half-inch circle. Now the aperture of the eye, through which the light paſſes, does not exceed one-tenth of an inch diameter, and the portion of the leſs circle, which correſponds to this ſmall portion of the greater circle, muſt be proportionably, that is, 1027,709,337,600 times leſs than one-tenth of an inch: and yet this infinitely ſmall point (if you will allow the expreſſion) affords light enough to make it viſible: or rather, affords light ſufficient to affect the ſight at that diſtance."

If

* Letters, &c. p. 275.

If the calculation, referred to in that paragraph, be just ; and we should suppose a single particle of light, though incomparably smaller, to be in bigness equal to that point, I would ask, whether the quantity of matter in such a particle would not be small in a greater degree than its velocity, equal to that of the sun's light, would be great ? If so, a particle of light in motion, agreeably to the foregoing supposition, may be here estimated 0, and its momentum not sufficient to remove the lightest dust ; much less to do as much execution as a twenty-four pounder, discharged from a cannon.

It is impossible to calculate the momentum, where the requisite data cannot be had : but supposing the candle-flame equal in bulk to a sphere of half an inch diameter, and to weigh as much as an equal bulk of air, viz. about one thirtieth part of a grain ; though in fact its gravity is incomputably less than that of air : then the square aforesaid will express the proportion, in which the density of the candle-light is diminished at the verge of the greater circle : and the same proportion of one thirtieth of a grain will express the weight of that light at the verge, viz. one 30,831,280,128,000th part of a grain ; which we will consider as the weight of a single particle of the sun's light. If the velocity of light be at the rate of 80,000,000 miles in six minutes, then its velocity will be 222,222 miles, equal to 14,079,985,920 inches, in a second. This number of inches, divided by 30,831,280,128,000, the supposed particles in a grain, will shew the degree of motion required in a body weighing one grain to give it a momentum, equal to that of a particle of light, upon the hypothesis assumed : which motion will be 456 millionth parts of an inch in a second, equal to one inch in 2190 seconds, or thirty six minutes and an half ; and is much

slower

slower than the hour-hand of a common clock: which, with its greater degree of motion, and much greater quantity of matter, does not give to the smallest bodies, placed in its way, any visible motion.

Precision in this calculation is not aimed at, and the nature of the subject does not admit of it: but it is apprehended, it will appear sufficiently evident from it, that light, even if its velocity were much greater than it is, and its gravity equal to that of air, to which, with great disadvantage to the argument, it has been, in that respect, compared, cannot drive before it the lightest dust, or, indeed, give it any sensible motion at all.

To the same purpose it may be further observed, that light reflected to the eye through a microscope and prism, would, it is apprehended, exhibit the same variety of colours, as light coming directly from the sun. In which case, the ray so viewed, (like the candle-ray, which has been considered as a single particle only) must be composed of a multitude of particles; and be a proof, that the particles of light are inconceivably smaller than the calculation supposes. This degree of smallness, however, represents them to be of great magnitude, compared with their real size: for when we consider, that the sun's light is diffused through the whole solar system, and much beyond it; and that a part of it, in that antenuated state, is reflected to us from the planets, in which reflection it undergoes, by its divergence, a further, and an extreme, attenuation: and especially when we consider the immense sphere, throughout which the light of the fixt stars is visible, particularly those of them, whose distance is so vast, that, at opposite points of the earth's orbit, they have no sensible parallax—the divisibility of light, and the proportionable tenuity of its particles, confound

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the imagination; and render human calculation inadequate to expreſs the preciſe degree of them, or the inconſiderableneſs of the momentum of thoſe particles.

This inadequateneſs is particularly applicable to the foregoing calculation: which was purpoſely made on the diſadvantageous principles aſſumed in it, to ſhew, that even on ſuch principles, the momentum of light could produce no viſible motion in the ſmalleſt bodies, that fall under our notice. But had the calculation been founded on the ſtate of the ſun's light reflected from one of the planets, for inſtance, the Georgium Sidus, lately diſcovered by Mr. *Herſchell*, the reſult would have been widely different; and we ſhould, in that caſe, have had a juſter idea of the momentum. The light reflected to the earth from that planet, whoſe mean diſtance from the ſun is ſaid to be 5,000,000,000 miles, is ſo extremely attenuated, that the momentum of a particle of it, transferred to a body, weighing a millionth part of a grain, would communicate to it ſo ſmall a degree of motion, that it would require millions of ages for that body to move the diminutive part of an inch mentioned in that calculation.

If theſe obſervations be juſt, it is apprehended they ſhew, with ſome degree of evidence, that a particle of light, notwithſtanding its prodigious velocity, cannot by its impulſe remove other bodies, or diſplace even the fineſt microſcopic duſt; and that the doctrine objected to, may be true, notwithſtanding the the firſt of the two objections, which have been made to it.

The ſecond propoſition, containing the other objection, is, that in caſe there are particles of matter, called light, continually driven off from the ſun's ſurface, the ſun muſt be exceedingly diminiſhed by ſuch a waſte of matter; and the planets,

nets, in consequence of it, must recede to greater distances from him, through the lessened attraction.

Here I beg leave to observe, that if the material system, in its present form, was not intended by its Creator to be perpetual, then the waste of the sun's matter, and the consequent disorder in the system, arising from the altered state of its gravitation, will only be a proof of that intention; and not operate against the truth of the doctrine.

That system, like every other, derived from the same original, doubtless has within itself the means of continuing in its present form, until the great and wise purposes of its Author shall be brought into effect, and compleatly answered.

With respect to the solar system, so far as its continuance depends on the sun, it seems calculated, notwithstanding the supposed waste of the sun's matter, to last for many ages: for the sun, by reason of its prodigious bulk, and the divisibility of its matter, must, from its own internal sources, furnish light to the system through a long tract of time, without being sensibly diminished. If those eccentric bodies, called comets, which have been thought intended to recruit the sun's waste of matter, do in fact answer that purpose, provision is then made for the preservation of the system, at least until those bodies shall have all successively fallen into the sun, and been expended. When that shall happen, if there be provided no further means of recruit, the system will begin to decay, and finally be reduced to a chaotic state: from which, like our earth, it may be restored in some new form, to answer the further purposes of the Creator. I mention our earth, as in the *Mosaic* account of it, its original is described in such a manner, as to give us the idea of its having been an old planet, by some means or other

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reduced to a chaos; from which it was renovated, and made suitable for the purposes, to which it has been applied.

There is nothing unreasonable, or improbable, in that idea: and if the earth was so renovated, it may be inferred from analogy, that in case the present system should go to decay, a new one, and perhaps a superior one, would arise from its ruins.

These observations are founded on the idea of the waste of the sun's matter, and its final dissolution, with that of the system depending upon it: whether gradually occasioned by that waste of matter, or more rapidly brought on by the general law of gravitation. In this view of things, the objection does not militate with the doctrine.

But perhaps it may be thought more philosophical, and that it would better comport with our ideas of the wisdom of the Creator to suppose, that when he created the system, he intended it should be a permanent one; and at the same time furnished it with the means of its own preservation. In which case, may it not be further supposed, particularly with regard to the efflux of light from the sun, by which its matter is conceived to be wasted, that he provided means, whereby the effluent particles, after answering the purpose of their efflux, should be returned to the sun, to answer again, in a constant succession, the same purpose.

I do not know, whether the hypothesis, suggested in the following queries, and relative to that subject, be admissible, or not. It is however offered for consideration.

It was primarily and specially intended to suggest a mean for preventing the ruin, to which the material system seems liable from the general principle of gravitation: but the same mean may possibly be applied to restore to the sun, in a regular succession

ceſſion, its effluent light ; and thereby obviate the evil effects, that might otherwiſe follow from the efflux.

Is it not conceivable, that round the ſolar ſyſtem, and the ſeveral ſyſtems, which compoſe the viſible heavens, there might have been formed a hollow ſphere, or orb, made of matter *ſui generis*, or of matter like that of the planets, and ſurrounding the whole : having its inner or concave ſurface at a proper diſtance therefrom ; beyond which ſurface light could not paſs, and between which, and the particles of light, there ſhould be a mutual repulſion ? And might not the ſun, or ſource of light, of each ſyſtem, have been ſo placed, in reſpect of each other, and the concave ſurface of the ſurrounding orb, that there ſhould be, by direct and repeatedly indirect reflections, an interchange of rays between them, in ſuch a manner, as that to each there ſhould be reſtored the quantity it had emitted ; and thereby the waſte of its matter be prevented : and this at the ſame time it diſpenſed its light to its particular ſyſtem ?

This uſe of ſuch an orb is here meant to be conſidered as a ſecondary or incidental one ; to which it might be applied : but the principal or primary uſe of it, as a counter-balance to the gravitating principle of the ſyſtems contained within it, will be ſeen in its proper place.

There is a remarkable phenomenon in the ſolar ſyſtem, to which the ideal one, juſt mentioned, bears ſome reſemblance, and by which it was ſuggeſted : I mean the ring or arch, which ſurrounds the planet Saturn. We are told by aſtronomers, that its width, and alſo its diſtance from Saturn, is about 25,000 miles ;—forming around that planet a beautiful arch, which may be deſigned, among other purpoſes, to increaſe its light and heat, by reflecting upon it, like a concave mirror, the ſun's

rays: of which, by reason of its great distance from the sun, it would not otherwise have had a sufficient quantity.

If Saturn were a luminous body *per se*, and the arch, (made of suitable matter, and properly constructed, for the purpose) entirely environed it, the whole quantity of light emitted from it, would be reflected back; and no waste of its matter arise from that emission. The same kind of hollow sphere or orb, surrounding, for instance, the solar system, would answer the same purpose. Its sun, being in the centre of the orb, would have all its light reverberated back to it: except the comparatively small quantity intercepted by the planets: a great part of which quantity would, by direct, and indirect reflections, be returned to the sun; and a quantity equal to the remainder, by means of volcanoes, and other internal fires in the planets, might be thrown off from them, and conveyed to the sun: whereby the equilibrium of the whole might be preserved.

Such an orb for a single system appears simple and plain; and such an one for the whole choir of systems, though seemingly more complicated, might yet appear equally suitable for the purpose, when its structure, and the laws and principles which governed it, and also the situation of the several systems relative to it, and to each other, should become known.

Its stupendous extension would be no objection to the supposition of its reality: for if the convenience and pleasure of the inhabitants of Saturn were a sufficient reason for furnishing that planet with its massy ring, the preservation of such a choir of systems, with the astonishing multitudes of their inhabitants, would justify and sufficiently support the supposition of such an orb: especially when it is considered, that besides answering the grand purpose of preserving those systems, it might, perhaps

haps like Saturn's ring, be provided on both ſides of it, with ample means of making it a ſuitable place for habitation: the habitation of myriads of millions of animate beings, equal or ſuperior to thoſe, which people our planetary ſyſtem.

Beyond that orb, at proper diſtances, it is conceivable, there might be other concentric orbs, equally ſuitable for habitation, and alike inhabited: including within them innumerable ſyſtems of planets, reſembling the ſolar ſyſtem, and like that animated, and adorning the infinite expanſe.

To this hypotheſis objections may be made, and ſuch as might prove it to be, like many an one which has preceded it, a mere philoſophical revery. But before it be ranked in that claſs, I would aſk, whether, if there be no ſuch orb, nor any thing to anſwer a like purpoſe, the law of gravitation, that univerſal law, on which the philoſophy of the immortal *Newton* is founded; by which, with ſuch admirable ſagacity, he has explained the phenomena of material nature; and on which he makes its preſervation depend, will not finally bring on its diſſolution? Or rather, whether the operation of that law would not long ago have brought it on?

The ſun of our planetary ſyſtem, and the ſuns (called fixt ſtars) of other ſyſtems, and therefore the ſyſtems themſelves, do probably, according to aſtronomical obſervations, poſſeſs the ſame relative place; or are, in reſpect of each other, fixt. But how are the exterior ſyſtems (ſuppoſing the whole not boundleſs) prevented from approaching towards the common centre of gravity: from which, if they have no revolution round it, (which the like obſervations make probable) they cannot be kept by a projectile or centrifugal force? Muſt they not conſtantly by that law be drawn, with an accelerating motion,

tion, towards that centre ; and finally, with the whole choir of systems, directed by that law, arrive at it with successive tremendous crashes, until the destruction of the whole would be compleated ? And could any thing but the interposition of the Power which created them, prevent it ?*

If such a catastrophè would be the effect of that law, would it not demonstrate the wisdom, and foresight of the Creator, to suppose, he provided the means of counteracting that effect at the same time he ordained the law ? And among the possible means of doing it, is it not conceivable, that a hollow sphere or orb, analogous to that above-described, might be one ?

It has been suggested in what way such an orb might prevent the gradual waste and decay of the material system. Let us now see, whether it might not be applied to prevent the swifter and more dreadful catastrophè, to which the law of gravitation, in certain circumstances, seems capable of subjecting that system.

The described orb, like every other body, would possess the gravitating principle, in proportion to its quantity of matter : which, in different parts of the orb, might be more or less dense, as the effect, intended to be produced, might require. Where a strong attractive power might be necessary, the density would be greater ; and so, *vice versâ :* and to assist or co-operate with it, a magnetic power might be superadded.

Thus

* Mr. *Whiston* observes, " It is by no means impossible, that all the bodies in the universe should approach to one another, and at last unite in the common centre of gravity of the entire system : nay, from the universality of the law of gravitation, and the finiteness of the world, in length of time, except a miraculous power interpose and prevent it, it must really happen." Discourse introductory to his Theory. p. 38.

Thus conſtituted, and furniſhed with thoſe, and other needful qualities, and ſurrounding the whole viſible choir of ſyſtems, might not the orb, by the principle of gravitation, either alone or aſſiſted, keep thoſe ſyſtems next to it, from being drawn towards the centre of gravity by their own, and the mutual action of the interior ſyſtems ? And might not thoſe ſeveral ſyſtems be ſo placed, and the denſities of the bodies reſpectively belonging to them, with the denſities of the ſurrounding orb, and conſequently their mutual gravitating power, be ſo regulated, and adjuſted, as to keep them all at the diſtance aſſigned them ; and forever prevent their approximating, either to the centre of the general ſyſtem, or to its ſurrounding orb : all of them together thus conſtituting an undecaying permanent whole ?

It has been obſerved by philoſophers, " that a body placed any where, within a hollow ſphere, which is homogeneous, and every where of the ſame thickneſs, will have no gravity, whereſoever it be placed : the oppoſite gravities always preciſely deſtroying each other."* But that obſervation cannot be applied to the hollow ſphere or orb, above-deſcribed : for by the deſcription, it is not homogeneous.—Nor need it be of equal thickneſs : which, however, is a circumſtance of no conſideration, if equal thickneſs, with different degrees of denſity in different parts, would anſwer the purpoſe.

The phenomena of nature, upon the ſuppoſition of ſuch an orb, would probably be the ſame, *cæteris paribus*, as now take place. Whether that ſuppoſition be ſupported by phenomena, and what other foundation there is for it, will be the ſubject of a future memoir.

* *Chambers's* Cyclopædia, under the word Gravity.

III. *Obſervations tending to prove, by Phænomena and Scripture, the Exiſtence of an Orb, which ſurrounds the whole viſible material Syſtem; and which may be neceſſary to preſerve it from the Ruin, to which, without ſuch a Counterbalance, it ſeems liable by that univerſal Principle in Matter, Gravitation.*

By JAMES BOWDOIN, *Eſquire,*
Preſident of the American *Academy of Arts and Sciences.*

AT the concluſion of a memoir, entitled, "Obſervations on Light, &c." which I have had the honour to lay before the Academy, it was intimated, that there are phenomena in nature, and other evidence, tending to prove the exiſtence of an orb, that ſurrounds the whole viſible material ſyſtem.

The evidence is,—phenomena and ſcripture.

The phenomena are,—the luminous girdle in the blue expanſe, called the Milky Way;—other luminous appearances in it; and the expanſe itſelf.

In regard to the luminous girdle, or Milky Way.—This phenomenon has been ſuppoſed to reſult from the combined luſtre of infinite multitudes of ſtars, too diſtant to be diſtinctly viſible. But although it be obſerved through teleſcopes, that there is a great number of ſtars in the Milky Way, on which circumſtance the ſuppoſition is founded, they appear as ſtars ſet in it; diſtinguiſhable from it; and not contributing to form the phenomenon.

The ſuppoſition not only diſagrees with the appearance, but is inconſiſtent with every philoſophical idea concerning thoſe ſtars. They are repreſented to be ſuns: each having its ſyſ-

tem

tem of planets revolving round it ; and conſequently requiring a ſpace proportioned to their number, and the extent of their ſyſtems : which ſpace, for ſuch multitudes of them as the ſuppoſition implies, muſt be beyond conception immenſe : and through which they muſt therefore be diſperſed at ſuch diſtances, that comparatively few of them could be viſible by us ; and that the whole together could not blend their light to cauſe that phenomenon.

On the contrary, the phenomenon ſtrikes us, as it may be ſuppoſed ſuch a luminous girdle would ſtrike, if its light were reflected from the concave ſurface of a far diſtant orb : to which, on the hypotheſis aſſumed, it had been propelled from the numerous ſyſtems, which the orb enfolds.

The ſame idea is ſuggeſted by the different degrees of its light, from a ſmall light to a faint ſcarcely diſcernible one ; by the frequent interruptions of it ; and by the large chaſm, which for a conſiderable ſpace, makes the girdle appear double, and very irregular.

Theſe appearances may be occaſioned by the ſituation of the earth in reſpect to thoſe parts of the orb, from which certain cones of light (preſently to be explained) are reflected ; and by the particular conſtruction, and configuration of thoſe parts ; by means of which theſe cones are broken, and irregularly reflected to the earth : whoſe different ſituations in its orbit, by reaſon of its great diſtance from the orb, would occaſion no ſenſible difference in the appearance.

With reſpect to the other luminous appearances in the concave expanſe, I beg leave here to introduce ſeveral obſervations, upon that ſubject, from two authors, who have diſtinguiſhed themſelves in the aſtronomical branch of ſcience.

One of them, Dr. *Smith,* in his Syſtem of Optics,* obſerves, that "*Hugenius,* in the year 1656, looking by chance through a large teleſcope, at three ſmall ſtars, very cloſe to one another, in the middle of Orion's Sword, ſaw ſeveral more as uſual. But the three little ſtars very near one another, (marked θ by *Bayer*) together with four more, ſhone out as it were through *a whitiſh cloud, much brighter than the ambient ſky:* which being very black, cauſed that lucid part to appear *like an aperture, which gave a proſpect into a brighter region.* He viewed it many time, and found it continued in the very ſame place, and of the ſame ſhape as the figure repreſents; [See plate II. fig. 8.] and called it *Protentum cui certe ſimile aliud nuſquam apud reliquas fixas potuit animadvertere.*"

He alſo obſerves, that "in the Philoſophical Tranſactions,‡ there is an account of a later diſcovery of *five more ſuch lucid ſpots,* though leſs conſiderable than this of *Hugenius*; *the middle* of which, we are there told, is at preſent in ♏. 19° 00′, with ſouth latitude 28° 45′; and that it *ſends forth a radiant beam* into the ſouth-eaſt, *as another* in the girdle of Andromeda *ſeems to do* into the north-eaſt. It is alſo there remarked, that though theſe ſpots are in appearance but ſmall, and moſt of them but a few minutes in diameter; yet, ſince they are among the fixt ſtars, as having no annual parallax, they cannot fail to occupy ſpaces immenſely great; and, perhaps, not leſs than our whole ſolar ſyſtem: *in all which ſpaces,* it ſhould ſeem, that *there is a perpetual uninterrupted day.*"

The

* P. 447—8.

‡ No. 347 *Jones's* Abr. vol. iv. p. 224.

Plate II.

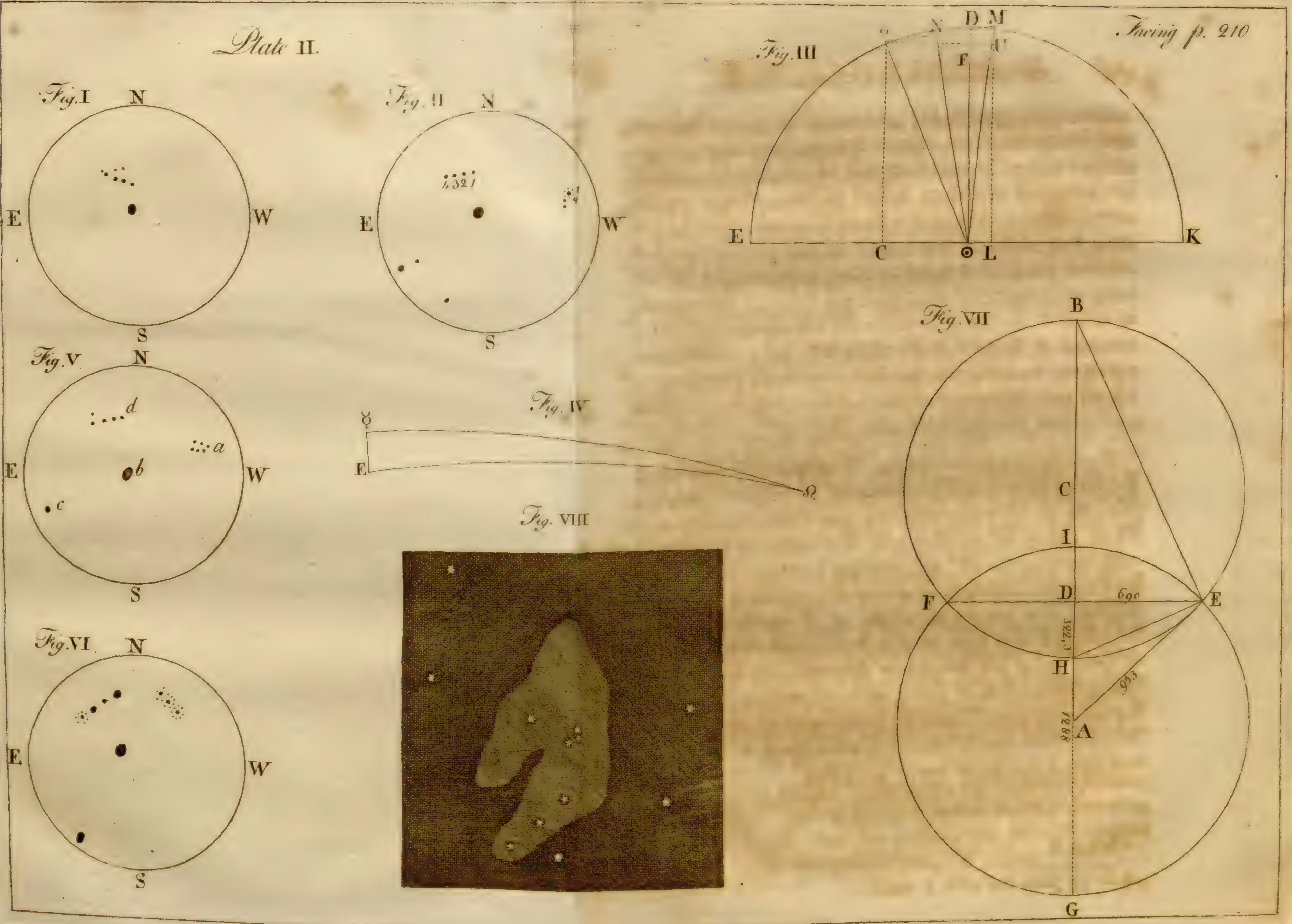
Fig. I
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Fig. VI
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Fig. VII
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1288
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Fig. VIII

The other author, Mr. *Ferguſon*, ſpeaking of the Milky Way, ſays, † "There is a remarkable tract round the heavens, called *the Milky Way* from its peculiar whiteneſs, which was formerly thought to be owing to a vaſt number of very ſmall ſtars therein: but the teleſcope ſhews it to be quite otherwiſe; and therefore *its whiteneſs muſt be owing to ſome other cauſe.* This tract appears ſingle in ſome parts, in others double."

"There are ſeveral little whitiſh ſpots in the heavens, which appear magnified, and more luminous, when ſeen through teleſcopes; *yet without any ſtars in them.*" Five of which ſpots he particularly mentions.

He next obſerves, that "cloudy ſtars are ſo called from their miſty appearance. They look like *dim ſtars* to the naked eye: but through a teleſcope, they *appear broad illuminated parts of the ſky;* in ſome of which is one ſtar, in others more.—But the moſt remarkable of all the cloudy ſtars, is that in the middle of Orion's Sword, where ſeven ſtars (of which, three are very cloſe together) ſeem to ſhine through *a cloud very lucid* near the middle, but faint and ill-defined about the edges. It looks like *a gap in the ſky*, through which one may ſee, as it were, *part of a much brighter region.*"

Theſe quotations, without making any comment upon them, ſhew, that the Milky Way is not owing to the ſtars contained in it; that the teleſcope ſhews it to be quite otherwiſe; and that it muſt be owing to ſome other cauſe: that in reſpect to the lucid ſpots, in ſome of them there are no ſtars; in others but few; and that one of them exhibits a remarkable appearance of an aperture, or gap, that gave a proſpect into a brighter region: that the ſpaces they occupy, though ſmall in appear-

† Aſtronomy. p. 339—40. Edit. 4th.

ance, are, perhaps, not leſs than our whole ſolar ſyſtem; and that in them it ſhould ſeem there is perpetual uninterrupted day.

From theſe phenomena it ſeems not improbable, that the Milky Way, and thoſe lucid ſpots, are parts of a concave body or orb, of the ſame nature with ſome of the other heavenly bodies; and, whoſe light, tranſmitted to us, exhibits thoſe phenomena, according to the laws and circumſtances, which regulate it.

There is another, and ſtill more remarkable phenomenon, that ſuggeſts the idea of ſuch an orb: I mean the blue concave expanſe, which ſurrounds, and appears to limit viſible nature; and which is the laſt to be conſidered.

It is thus explained by Sir *Iſaac Newton*; who obſerves, "that all the vapours, when they begin to condenſe and coaleſce into natural particles, become firſt of ſuch a bigneſs as to reflect the azure rays, ere they can conſtitute *clouds* of any other colour. This, therefore, being the firſt colour they begin to reflect, muſt be that of the fineſt and moſt tranſparent ſkies; in which the vapours are not arrived to a groſſneſs ſufficient to reflect other colours."*

By this explanation it appears, that the cauſe of this phenomenon exiſts within the earth's atmoſphere. If it really doth exiſt within it, the phenomenon, from the aſſigned cauſe of it, ſeems to be nothing more than a blue tranſparent cloud, more or leſs extenſive, in proportion as the atmoſphere may happen to be leſs or more charged with other clouds.

If this were the cauſe, would not the heavenly bodies, in a clear ſky, partake of the colour of that cloud, and appear blue, or be tinged with it, by means of their light paſſing through the

* *Chambers's* Cyclopædia, under the word Blueneſs.

the blue cloud ? And would not this appearance indicate, that the blue rays of their light were tranſmitted, and the other coloured rays, for the moſt part, reflected from the atmoſphere ? Would not that tranſmiſſion of the blue rays occaſion all bodies around us to appear blue, ſo long as the atmoſphere, continuing clear, ſhould exhibit the blue cloud ? And would not the colours of thoſe bodies vary as other coloured clouds ſhould ſucceed and predominate ?

Would not this reflection of the other coloured rays occaſion, not only a decreaſe of light, but, with reſpect to the ſun, a great diminution of its heat ? If the ſeveral different coloured rays do each, in reſpect to heat, produce an equal effect ; and all but the blue rays are reflected, ſhould we not, in a clear day, be deprived of ſix ſevenths, or a proportionable part, of the ſun's heat, which the ſeven ſorts of rays, had they been all tranſmitted, would have afforded ?

Such appearances and effects might have been expected, if the aſſigned cauſe produced the phenomenon : for the ſun's light and other light, and alſo bodies in general, whatever be their colour, being viewed through a medium of any original colour, will appear of that colour, or ſtrongly tinged with it. But it is apprehended, that no ſuch appearances and effects have ever been obſerved ; and, therefore, that there is reaſon to doubt the reality of the cauſe aſſigned : the inſufficiency of which may further appear in the courſe of theſe obſervations.

But how is the exiſtence of the orb deduced from the phenomenon ?—In the ſame manner as the exiſtence of the other heavenly bodies, and the exiſtence of the bodies around us are deduced : namely, from the uniformity and permanency of their viſible qualities, or phenomena.

In

In regard to bodies around us, whenever by sight we have been impressed with certain ideas of colour, form, and magnitude, corresponding to bodies near us, and at an approachable distance, we have found, by constant and uniform experience, derived also from, and confirmed by, every other sense and means of information, that such bodies do really exist: and having thus from experience gained the knowledge, that certain phenomena do infallibly indicate the existence of those bodies, the phenomena themselves do then alone become the undisputed evidence of that existence.

Nature is simple and uniform in its operations. From the same cause follow like effects; and these indicate the same cause. Bodies of every kind, through the medium of light, produce their respective phenomena, and these demonstrate the reality of those bodies.

From these principles we infer the reality of those terrestrial bodies, which, by reason of their situation and distance, can only be the objects of sight: and from the same principles we also infer the reality of the heavenly bodies, the planets, and fixt stars. If this last inference be just, is it not equally just to infer, from the same principles, the reality of the blue circumambient expanse: that is, that it is a real concave body, encompassing all visible nature: which is the exact description of the concave surface of the orb above-mentioned.

There is one appearance of the blue expanse, which may be thought to militate with the foregoing account of it.

In a clear day, it appears of a brighter blue than in the night, occasioned by the sun's light reflected to us by the earth's atmosphere. From which circumstance it might be supposed, that the cause of the phenomenon doth exist within the atmos-

phere,

phere, and is the atmoſphere itſelf, or its vapour. It is apprehended, however, that this would be a miſtaken ſuppoſition; and that the appearance may be explained on principles, which will not only invalidate the ſuppoſition, but further ſhew the inſufficiency of the cauſe, to which the phenomenon has been aſcribed.

For that purpoſe it may be obſerved, that the atmoſphere being inviſible, muſt be without colour; and has, perhaps for that reaſon, no greater diſpoſition to tranſmit or reflect to us the blue rays of light, whether of the ſun or ſtars, than thoſe of the other colours: and, therefore, if the phenomenon be produced by means of the blue rays of thoſe luminaries (which I ſhall attempt to explain) the atmoſphere cannot be the cauſe of that production.

With reſpect to the vapours in the atmoſphere, which, in a particular ſtate, are ſaid to occaſion the phenomenon, they being of different degrees of groſſneſs or denſity, muſt arrange themſelves according to that denſity, or their ſpecific gravity. If then any of the ranges conſiſted of vapour, in a proper ſtate to tranſmit or reflect to the eye the blue rays only, the effect of it would be deſtroyed, or changed, by the groſſer vapour in the lower range. Or if it ſhould ſo happen (which ſeems very improbable) that the whole body of vapour ſhould conſiſt of particles of the due ſize, and in the proper ſtate, to reflect the blue rays, it could not long continue in that ſtate, by reaſon of the changeable nature of the vapour, and the numerous cauſes, that are conſtantly operating to produce a change in it. But the phenomenon is uniform and premanent; and therefore muſt be the effect of an uniform and permanent cauſe.

If thefe obfervations have any foundation, neither the atmofphere nor its vapour, affifted by, or affifting, the *direct* light of the fun and ftars, can be the caufe of the phenomenon.

The atmofphere, however, or its finer and tranfparent vapour, contributes to the brighter hue of the phenomenon by day: which may be thus explained.

The fun's light in its mixt ftate, reflected by the atmofphere, or by the tranfparent vapour floating in it, enters the eye at the fame time with the blue light of the expanfe; and both together delineate on the retina an image, formed by their united rays, each producing its effect. The light from the expanfe exhibiting the blue image; the light from the fun illuminating or brightening the image; and both together impreffing the idea of that phenomenon, as it is difplayed in a clear day.

If it fhould be afked, from whence the concave expanfe derives its light, the anfwer is—from the numberlefs planetary or folar fyftems, which it includes: and particularly from thofe in the neighbourhood of it, which directly anfwer the purpofe of enlightening, and in other refpects, accommodating its inhabitants.

This light, tranfmitted to the expanfe through its atmofphere, is reflected back directly and indirectly to the fyftems from which it iffued: to be again, in a due fucceffion, remitted to, and reflected from, the expanfe. By fuch a reciprocation, and mutual interchange of light with each other, and among themfelves, the feveral parts may be fupplied with the quantity they had refpectively emitted; and the equilibrium of the whole maintained: whereby the evils, that might otherwife enfue from the wafte, or undue diftribution of its matter, and the confequent alteration of its gravitation, might be prevented.

To different ſyſtems, according to their ſituations, the expanſe may exhibit very different phenomena. Although to our ſyſtem, or to us on this planet, it exhibits the blue concave of an all-ſurrounding orb; which, in the Milky Way, and in ſome other parts of it, ſhines with a brighter light, it may to other ſyſtems appear of other colours; and exhibit to ſome of them in ſucceſſion, according to their ſituations, the ſeveral primitive colours in the order, in which the rays of thoſe colours are ſeparated and claſſed.

Of one of theſe exhibitions, that of the blue colour, we have ocular demonſtration. But why ſhould the expanſe appear to us blue, rather than green, or of any other primitive colour? If that appearance can be explained by the refrangibility of light, or by the ſeparation of it into its ſeveral colours, as perhaps it can, the other appearances of the expanſe to other ſyſtems, naturally, if not neceſſarily, follow.

Experiments prove, that light is compounded of differently coloured rays; and that after it has paſt through different mediums properly diſpoſed, the rays are refracted, or ſeparated and claſſed, according to their different refrangibility; and ſhew thoſe colours in the order juſt mentioned: that the three moſt refrangible of them, the blue, the indigo, and violet, which poſſeſs one half of the ſpace ſpread over by the whole, are ſo nearly allied in colour, that the laſt, when conſiderably ſpread, are ſcarcely to be diſtinguiſhed from the neighbouring blue: for which reaſon, thoſe three claſſes appear as one, at a great diſtance from the refracting medium: and the blue thus circumſtanced, and uniting thoſe claſſes, may therefore be ſaid to poſſeſs a ſpace equal to the ſpace occupied by all the reſt. That from any ſegment of a hollow ſphere, ſuch, for inſtance, as a

concave mirror, whose arc does not exceed fifteen or eighteen* degrees; the cylinder of rays falling upon it parallel to its axis, will, if there be no refraction, be reflected to a focus round that axis: the focus being nearly equidistant from the pole of the segment, and the centre of its sphere: and that those rays, if previously refracted, and classed into their several colours, will, in their divergence from the focal point, shew those colours in a reversed order: the refraction, however, occasioning an alteration in the position of the focus, and the diverging cone.

To apply some of these observations, it may be supposed, that the interior side of the expanse has, in general, an uniform surface, which may be conceived as composed of a multitude of segments, each of them not exceeding a given arch: that it is furnished with an atmosphere, possessing, in some peculiar mode, the power of refracting light, of distributing its rays into their respective classes, and transmitting them to the expanse; which also may be conceived as assisting, by its reflecting power, in their classification: that the transmitted rays would, in their classed state, be reflected from it in all directions; and that such of them (by far the greatest † part of the whole) as should come

* 's *Gravesande's* Natural Philosophy. Book III. ch. xv. prop. 813.

† That these parallel rays (parallel, I mean, to any and every conceivable diameter-line of the expanse) must constitute the greatest quantity or proportion of the reflected light, will be manifest from these considerations:—That they come to every segment or part of the expanse from the opposite part of it, and from the systems situated between such opposite parts: that the distance of any two opposite parts from each other, equal to the diameter of the expanse, is the greatest that can take place within it: that there must, therefore, be, in the space between them, a greater number of systems supplying the expanse with light, than there can be in any

come to the atmoſphere in parallel lines, or in cylinders, whoſe axes were diameter-lines of the expanſe, and whoſe baſes were equal to thoſe ſegments, would paſs through the atmoſphere to the correſponding ſegments of the expanſe, and be reflected from them; and afterwards, in the ſame claſſed ſtate, unite in a focus, from which they would diverge, and exhibit their ſeveral colours.

To give ſome idea, though an imperfect one, of that focus, the reflection and convergence may be conceived as made (ſomewhat in the manner above-repreſented) from the ſegments compoſing the whole ſurface of the expanſe: that each ſegment would reflect a cone of rays, terminating in a focus; and that the united *foci* of thoſe cones, which muſt be conſidered as coming from all quarters of the expanſe, would conſtitue its general focus.

In ſome ſuch diſpoſition, and ſtate of things, as here repreſented, it is conceivable, that the ſyſtem-light, tranſmitted to the expanſe through its atmoſphere, might be reflected from thoſe ſegments; and for the moſt part converge in cones towards a general focus: where, by means of the refraction and ſeparation, it had undergone in that tranſmiſſion and reflection, it would be, in each cone, arranged or claſſed, according to the different refrangibility and reflexibility of its rays. After the rays had paſt the boundary of their focus, they would interſect each other, and form new and reverſed cones, or conic

 figures:

any extra-central direction; and that this may be affirmed of every two oppoſite parts or ſegments in the whole ſurface of the expanſe. The effect of the atmoſphere, in regard to the refraction, is not here noticed. Theſe rays, like the ſun's rays at the earth, are conſidered as parallel, by reaſon of the great diſtance of the radiant bodies, and the conſequent extreme minuteneſs of the angle of divergence at ſuch a diſtance.

figures: in which each ſort of the coloured rays, as before the interſection, would generally be together; and in that aſſociated ſtate, continually diverge in proportion to their diſtance from the line of interſection.

But perhaps the whole of this effect, the claſſification of the rays, may be cauſed by the reflecting power of the expanſe: which, in that caſe, would receive the rays in the ſame mixt ſtate as the direct ſolar light comes to the earth: with reſpect to which, we know that it frequently undergoes a claſſification by reflection, as well as by refraction.

In either caſe, as the three moſt refrangible, and reflexible claſſes, at a proper diſtance from the focus, are not to be diſtinguiſhed from each other, but all appear blue: and as the blue, at that diſtance and beyond it, doth therefore poſſeſs ſo large a portion of the interior ſpace of the expanſe, it is conceivable, that many ſyſtems may be ſo placed, as to be on all ſides in the direction of the rays of that colour; and to which the whole expanſe would, for that reaſon, appear blue.

With reſpect to the earth, it is probably ſo ſituated as to be in all parts of its orbit, principally within the limits of ſuch claſſes as are compoſed of the blue rays; and partly within the verge of claſſes, whoſe rays, by reaſon of their imperfect ſeparation being in a mixed ſtate, exhibit a brighter light. The predominant colour, therefore, of the expanſe, as it reſpects the earth, is blue; with interſperſions of a brighter light, ſuch as the Milky Way, and other lucid parts of the expanſe: whoſe irregular appearance, in the Milky Way, may be owing (as hath been already ſuggeſted) to the particular conſtruction and configuration of its parts; the brightneſs of which ſeems to

intimate

intimate ſome peculiarity in their conſtitution, and in the circumſtances attending them.

Nature thus exhibiting, on a broad ſcale, phenomena, which our little experiments can exhibit only in miniature ; and of which thoſe experiments ſometimes lead to a happy explanation.

Whether the foregoing be ſuch an explanation, or wholly chimerical, in reference to the colour of the expanſe, does not affect the expanſe itſelf : whoſe exiſtence, conſidered as an all-ſurrounding orb, may be real, although the aſſigned cauſe of its colour be demonſtrably without foundation.

From the ſeveral phenomena above-mentioned, unleſs the evidence ſuppoſed to ariſe from them be futile, or inadmiſſible, there is reaſon to conclude, that an all-ſurrounding orb doth really exiſt ; and that the blue expanſe is that orb.

It is an obſervation of Sir *Iſaac Newton*, " that the main buſineſs of natural philoſophy, is to argue from phenomena, without feigning hypotheſes ; and to deduce cauſes from effects, till we come to the very firſt cauſe, which certainly is not mechanical ; and not only to unfold the mechaniſm of the world, but chiefly [among others that are mentioned] to reſolve theſe, and ſuch like queſtions, viz. Whence is it, that the ſun and planets gravitate towards one another, without denſe matter between them ? and what hinders the fixt ſtars from falling upon one another ?*

Agreeably to the foregoing obſervation, the author of this memoir having adduced certain phenomena, he hopes not impertinently, has endeavoured, not only to argue from them, and to deduce the cauſe from the effects, but to reſolve that great queſtion

* Opticks. p. 344. 4th edit. 8vo.

question concerning the fixt stars, and the heavenly bodies in general, namely, What hinders them from falling upon one another, and thereby involving the whole in ruin?—Whether his endeavours have been successfully applied, those who are conversant in subjects of this nature, are best qualified to judge.

In regard to the subject in hand, there seems to be a happy co-incidence between phenomena and scripture; and, therefore, in further evidence of such an orb, and in evidence of several other orbs similar, and concentric to it, we may recur to scripture: several passages of which appear applicable to that purpose.

It seldom happens that natural philosophy is made to borrow assistance from thence: but though scripture may not be intended to instruct us in the philosophy of material nature, it may nevertheless give, and be intended to give, some hints of its constitution, or general system.

As the passages referred to, do not need any laboured comments, a very few observations will suffice to explain and apply them.

A remarkable one, and which may serve, in some measure, to elucidate the rest, is this passage, "It is God that buildeth his stories in the heavens."* In the *English* translation, which agrees with the *French*, with the *Latin* of *Castellio*, and of *Tremellius* and *Junius*, the marginal reading, referring to stories, is spheres and ascensions. The former explanatory of stories: the latter, another word for the *Hebrew*; and which answers to the *Greek* of the *Septuagint*. All which, both separately and together, give the idea of a succession of concentric spheres, ascending one above another, like the stories of a magnificent building:

* *Amos*, ch. ix. 6.

building: and, agreeably to that idea, though on very different principles, perhaps thoſe of the *Ptolemeian* ſyſtem, the text has been explained.*

This conſtruction, which appears to be a natural one, gives a meaning to the text,—a meaning illuſtrative of the omnipotence of the Architect: and, at the ſame time it elucidates ſome other texts relative to the ſubject, it is perfectly deſcriptive of the concentric ſpheres, or orbs, above-mentioned.

The ſame idea is intimated in the ſhort account given of the creation by *Moſes*, who ſeems to refer to two firmaments.—The firſt he mentions is limited to the earth and its atmoſphere; and the other is that in which the fixt ſtars do appear.

It is this latter, that is here to be conſidered: concerning which, "God ſaid, let there be lights in the firmament of heaven;" and concerning which it is declared, that "God ſet thoſe lights in the firmament."||

The radix of the *Hebrew* word, tranſlated firmament, "is applied to God's ſpreading out the ſky; to the firmament, or ſpacious

* Qui ædificat in coelo (in ſupremis cœlis) aſcentiones ſuas—ſphæras ſuas—gradus ſuos: i. e. orbes coeleſtes, qui ſunt velut gradus; unus ſupra alterum.

Poli ſynopſis in loc.

|| Gen. ch. i. v. 14. 17.

Mr. *Whiſton*, whoſe explanation of the *Moſaic* account of the creation is natural, and in general ſeems to be juſt, makes no diſtinction of firmaments: which, however, he might have made, without injuring his theory; and which his own rules of interpretation would have juſtified.

The upper firmament, or blue expanſe, in which the heavenly bodies were "ſet," he might have included, together with them, in the work of the fourth day, or year, as it was rendered viſible at the ſame time, by means of the earth's atmoſphere, in that year, becoming tranſparent: which atmoſphere, according to his theory, is the [other] firmament, or expanſe. He ſuppoſes, the earth had no rotation about its axis until the deluge; and, therefore, that its annual revolution round the ſun, would occaſion the antediluvian day to be exactly commenſurate with the year.

ſpacious extenſion, which is ſpread abroad between the earth and the clouds: *as alſo to that other* firmament, or ſpacious extenſion, which is above the clouds, where the heavenly bodies are placed."*

The original word † means, not only firmament, but expanſe, or ſpacious extenſion. In the *Engliſh* tranſlation, and alſo in the *Greek* of the *Septuagint*, it conveys the idea of ſomething firm and ſolid. Some other tranſlations adopt the other acception of it. It ſeems to include both; and in that caſe means ſomething ſolid, and ſpaciouſly extended.

This explication of the term, connected with the appearance of this firmament, or expanſe, gives us the intimation of a ſolid and ſpaciouſly extended orb, or ſphere: and anſwers to one of the ſtories, which God built in the heavens.

"The heavens ‡ declare the glory of God: and the firmament ſheweth his handy-work."—Here is a clear diſtinction between the heavens and the firmament. By the former, are meant the heavenly bodies; and by the latter, the firmament, or expanſe, in which they appear.

The ſame obſervations may be applied to this, as have been applied to the foregoing paſſage.

Another, and more deſcriptive of ſuch an orb, is the following one: "Haſt thou ſpread out the ſky: which is ſtrong, and as a molten looking-glaſs:"‖ or, as a mirror made of poliſhed

* *Taylor's Hebrew* Concordance, root 1826.

† The author of this memoir, being unacquainted with *Hebrew*, ſpeaks of its meaning by information only.

‡ Pſalm xix. 1. Cœlum hoc ſtelliferum. Poli Syn.

‖ *Job* xxxvii. 18. An expandiſti cum eo (eum adjuvando) æthera, vel cœlos, vel firmamentum? Hoc græci vocant ſtereōma quod—firmum ſit, et ſuâ ſe velut virtute

lished metal. The forementioned *French* and *Latin* versions, and the *Greek* of the *Septuagint*, do, in this passage, all concur with the *English*, in representing the sky as strong, firm, and solid. The *Septuagint* especially, expresses this idea with peculiar force; as doth also the *Hebrew* original: which, in this place, resembles the sky to a *speculum*, or mirror, " made of polished metal."*

" The elegant simile of the mirror cannot be understood without recollecting, that their looking-glasses (or mirrors) were made of metal highly polished."†

This description shews the sky to be, not only firm and solid, but remarkably adapted to reflect light; and so far intimates the cause, why it is visible. The sky here, as the firmament in a former clause, corresponds to one of the stories, which God built in the heavens.

There are other passages, which mention the spreading out, and stretching out, of the heavens; and this as declarative of the discretion, the understanding, the wisdom, and power of God. But if it be a mere appearance, arising from the atmosphere-vapours, in a particular state reflecting to us the blue rays of light; or if it be a mere circumstance attendant on, or resulting from, the atmosphere; and doth not indicate the real ex-

virtute contineat, nullâ re nitens. Æthera, vel cœlos—quì solidissimi—quì sunt fortes: item sicut speculum fusum, sive concretum.—Cœlos, quibus *firmitas* tribuitur Prov. viii. 28. unde poetæ cœlum vocârunt kalkeon ouranon. Specula fusa intellige ex ære vel chalybe.—Vox *fortes* soliditatem denotat.—Cœlum,—solidissimum ut simul cohæreat. Poli Syn.

* Fusum, firmum, validum, instar fusi et consistentis metalli. *Taylor's Hebrew* Concordance, root 783. 26.

† *Scott's* Book of *Job*, p. 354.

iſtence of what is declared to be thus ſpread or ſtretched out, it is then, in a comparative view, but an inferior inſtance of wiſdom and power: by no means ſuch an inſtance of them as to entitle it to be mentioned in the climax, in which it is found: much leſs to be the head, or principal member, of it.

The following, which is one of thoſe paſſages, and in the ſenſe of which the aforenamed verſions concur with the *Engliſh*, will ſhew the climax.——" He hath made the earth by his power: he hath eſtabliſhed the world by his wiſdom; and hath ſtretched out the heavens by his underſtanding."*—The earth, including its atmoſphere—the world, or heavenly bodies collectively—the ſtretched-out heavens, or blue expanſe. This remarkable climax, aſcending in dignity and importance, ſhews, that the laſt and principal member of it, the expanſe, is not only diſtinct from the earth, and the whole ſyſtem of heavenly bodies, but that it ſurpaſſes them in excellence; and that it is the capital, among the works of the viſible creation. The deſcription of it, and its rank in the climax, indicate, that it is the ſame firmament or expanſe, above-deſcribed; that the ſame obſervations are applicable to it; and therefore, that this, and the parallel paſſages alluded to, may be adduced in further evidence of its exiſtence; and, conſequently, of the exiſtence of an all-ſurrounding orb.

The ſame idea is held forth in a part of the addreſs of wiſdom in Prov. viii. 27—29: the ſenſe of which may be expreſſed in the following tranſlation; which differs from the common *Engliſh* tranſlation, no further than the apprehended ſenſe of the text makes neceſſary. A few explanatory notes are interſperſed, by way of illuſtration.

Wiſdom

* *Jer.* ch. li. 15.

Wiſdom ſpeaking, ſays,—verſe 27. "When God prepared the heavens [the whole ſyſtem of viſible nature] I was preſent. When (with reſpect to the heaven) he ſet an orb around the ſuperficies of the depth [the immenſe ſpace included within the orb: in reference to which, that ſpace may be juſtly called the depth]: v. 28. When he gave ſolidity and ſtrength to (that orb) the ſky above; and when he eſtabliſhed its fountains of waters [its interior and exterior atmoſphers]: v. 29. When (with reſpect to the terraqueous globe) he gave to the ſea his decree, that its waters ſhould not paſs their bounds: and when he appointed the foundations of the earth, then I was by him."

If this tranſlation and illuſtration, be juſt, the text, which only gives the great out-lines, or capital parts of creation, ſtrongly impreſſes the idea, that there is an orb ſurrounding all viſible nature; that it is ſtrong and ſolid; and that it is furniſhed with an interior and exterior atmoſphere: all which is further deſcriptive of one of the ſtories, that God built in the heavens.

In ſupport of the tranſlation and illuſtration here given, I had collected, in a marginal note, a number of authorities from *Pool's* Synopſis: but it being ſomewhat long, and thoſe who are qualified to judge in the matter, being able to recur to the Synopſis, it is omitted.

Beſide thoſe authorities, and in further ſupport of the tranſlation, may be adduced the 148th pſalm: where are enumerated, in a regular ſucceſſion, the heavenly bodies, which compoſe the material ſyſtem:—the ſun, moon, ſtars, heavens, and waters above the heavens.

 The

The distinct notice there taken of those bodies, and the arrangement of them according to nature, make it probable, that by the heavens (in that passage, as in some others) are intended the orbs, that have been described. And, in regard to the waters above the heavens, they do plainly intimate, that those orbs are each, like the earth, environed by an atmosphere replenished with waters, to answer the same purposes with the atmospheric waters of the earth.—Of that passage, there will presently be occasion to take some further notice.

If some happy genius, well versed in *Hebrew*, and the philosophy of nature, would arrange in due order, and faithfully translate, those parts of scripture, that in any respect refer to the constitution and economy of nature, and this with a view of reconciling them to nature, we should probably find, that scripture philosophy and natural philosophy would mutually illustrate each other. Such a translation and illustration would be a real acquisition to science; and might lead to discoveries, of which, at present, we can form no idea.

One quotation more, amidst a further number that might be offered, will close the evidence.

" The heaven, and the heaven of heavens, and the earth also, are the Lord's." " Thou hast made heaven, the heaven of heavens, with all their hosts: the earth, and the seas, and all things in them." " Praise him, ye sun and moon, ye stars, ye heavens of heavens, and ye waters above the heavens."*

There are other passages of like import: but these containing all the varieties of expression I have observed concerning the material heavens, or system of nature, may be thought sufficient.

That

* Deut. x. 14. *Neh.* ix. 6. Ps. cxlviii. 3, 4.

That the material heavens are here intended, there can be no room to doubt, as they are mentioned in connection with the earth—with their hosts—with the earth and seas, and the things contained in them—with the sun, moon and stars—and with the waters above the heavens. They are evidently considered here as forming, in conjunction with those other bodies, one vast system; whose several constituent parts are, in the last clause of the quoted text, ranged in the order, in which it is natural to speak of them; and in which, reckoning from the centre of our solar system, they do in reality exist.

Here is a plain descrimination between the heaven; the heaven of heavens; and the heavens of heavens: which must imply some essential difference between them. To suppose the contrary is to confound language, and involve it in uncertainty. It would be to suppose those expressions void of meaning; and would be treating scripture with the indecency, to which no other book, appearing to be dictated merely by common sense, would be entitled. Those expressions, then, necessarily imply some essential difference in the objects of them: and what that difference is, the quotation from *Amos* points out. The gradation, respecting the heavens, is remarkable; and without recurring to any thing else, suggests the idea of stories in them, orb beyond orb, as above explained. The series too, in which they are mentioned—the sun, moon, stars, heavens, and waters above the heavens—and the place they hold in the series, suggest the same idea: which is strengthened and confirmed by the express declaration, that in fact there were such stories built by the Almighty: or, as it is otherwise expressed, that "he made them with all their hosts."

The

The laſt member of the ſeries is the waters above the heavens. Theſe waters, arguing from analogy, ſeem to indicate, and to be deſcriptive of atmoſpheres, that ſurround thoſe orbs, amply provided, like our atmoſphere, with waters, and other elements, proper for the ſupport of animal and vegetable life; and for other important purpoſes.

The number of thoſe ſtories, or concentric orbs, ſeems indefinite. The gradation clearly denotes a plurality of them: each having its hoſts—its ſuns and planets, or ſyſtems. The ample ſpaces between them, like the ſpace infolded by the orb, to which we more immediately belong, are beautified by thoſe glorious bodies, which, within each of the orbs, conſtitute ſyſtems innumerable, ſerving the like noble purpoſes, which our ſolar ſyſtem is calculated to ſerve, and doth ſerve.

The foregoing paſſages of ſcripture thus interpreted, appear to agree, in their reſult, with the phenomena above-mentioned; and, like them, to be naturally, and without force, applicable to the purpoſe, for which they were produced. Such agreement, it is apprehended, ſhews the propriety and fitneſs of the interpretation: as, on the other hand, a diſagreement with phenomena would prove the unfitneſs or falſity of any interpretation; and manifeſt it to be totally inadmiſſible.

When ſcripture and phenomena thus agree, they mutually elucidate each other; and, in that caſe, what is deducible from the one, is confirmed by the other. As, therefore, thoſe paſſages agree with the phenomena, they both together corroborate the evidence, which each afforded ſeparately, of the exiſtence of an interior orb.

With reſpect to the exterior orbs, the evidence for them muſt reſt on ſcripture. There can be no phenomena, from which

which to deduce their reality: unless the aperture, or gap aforementioned, with what it discloses, be admitted as such.

The phenomena, exhibited through that aperture, are indeed remarkable; and may indicate an exterior orb, or the bright region between that, and the orb, which more immediately surrounds us: in which bright region, as well as in some other of the lucid spaces in the expanse, there seems to be an uninterrupted and perpetual day.

If in fact there be such an aperture, the same appearances with those, from which it was deduced, may indicate other apertures in the other lucid spaces, and in the Milky Way: for the ascertaining of which, the observations of the ingenious Mr. *Herschell*, with his largest magnifiers, should he think proper to apply them for that purpose, might happily conduce.

Among the purposes, for which those apertures were intended, if they really exist, this may be one,—to give to the *intra-orbic* and *trans-orbic* systems some intimation of each other, and of their mutual relation; and to afford them a glimpse of the grand complicated system, of which they are parts.

The immensity of those orbs doth not invalidate their existence: on the contrary, immensity is so congenial to our ideas of the Creator, and his works, that it affords, as applied to those orbs, an internal presumptive proof of their reality.

On the supposition of their existence, what an assemblage of glorious bodies do they exhibit! peopled by an unlimited variety of beings, and arranged in a gradation beautiful and astonishing! Trace the gradation from the smaller to the larger planets, circling around their sun, and with him forming a magnificent system! Trace it from that system, through successive systems, to their surrounding orb! Trace it from orb to

orb,

orb, and through their several hosts of systems up to the superior orb, and its ambient atmosphere! Trace it in every possible direction, from the common centre to the utmost verge of that atmosphere, and the most wonderful phenomena, in a rapture-inspiring succession, strike the mental eye! impressing the idea of a complete whole, self-balanced, and held in union by universal gravitation! exhibiting a superlatively grand system of systems, embosomed in the infinite, all-comprehending essence of the Creator!

Grand and magnificent as this system is, there may be another incomparably more so; composed of myriads of such systems, governed by the same laws, and with it surrounded by an immense orb, to counter-balance the gravitation of the included systems.

That other system may be a part of a still more splendid one, formed on the same plan; and this latter may enter into the composition of other systems, beyond comparison superior to it: each succeeding system, in a regular progression, rising in dignity and splendour. And thus we may go on, enlarging our idea of those systems, indefinitely.

What is there to check that idea, when we consider the infinity of space, in connection with the infinite wisdom, power and benevolence of the Author of nature; and at the same time reflect, that infinite space is the proper, and the only adequate theatre for the display of those perfections, and of such a character?

This hypothesis, by introducing solid orbs, may possibly, on a superficial view of it, be thought a revival of the ancient or *Ptolymeian* System, and to grow out of it. But on the contrary, it will be found, upon examination, totally inconsistent with

with it; and to be in reality the offspring of the new philoſo-phy: derived from the grand principle of that philoſophy—univerſal gravitation.

Upon the whole:—The hypotheſis, ſo far as it relates to the exiſtence of the interior orb, immediately ſurrounding the viſible heavens, the author of it apprehends to be a probable deduction from the principle of gravitation; and to be deducible alſo from phenomena and ſcripture. He offers it for conſideration, with the hope, that if it ſhould appear not wholly groundleſs, it may be productive of a happier illuſtration.

IV. *An Account of a very uncommon Darkneſs in the States of* New-England, *May* 19, 1780. *By* SAMUEL WILLIAMS, *A. M. Hollis Profeſſor of Mathematics and Philoſophy in the Univerſity at* Cambridge.

THE beſt method to promote the knowledge and ſcience of nature, is to proceed by way of obſervation and experiment. The general courſe, productions, and laws of nature, ſhould be carefully and ſteadily attended to: and when any new phenomena appear, all the circumſtances and effects, relating to them, ſhould be particularly noted and collected. In this way we ſhall be moſt likely to arrive at the knowledge of their cauſes: or, at leaſt, we ſhall prepare thoſe materials which may enable poſterity to determine, with certainty and preciſion, on what at preſent may be but imperfectly underſtood.

With this view, I ſhall endeavour to lay before the Society, as particular an account as I can collect, of the uncommon darkneſs which took place in the ſtates of *New-England.*

The *time* of this extraordinary darkneſs, was May 19, 1780. It came on between the hours of ten and eleven, A. M. and continued until the middle of the next night; but with different appearances at different places. As to the *manner* of its approach it ſeemed to appear firſt of all in the S. W. The wind came from that quarter, and the darkneſs appeared to come on with the clouds that came in that direction. The *degree* to which the darkneſs aroſe, was different in different places. In moſt parts of the country it was ſo great, that people were unable to read common print—determine the time of day by their clocks,

clocks or watches—dine—or manage their domeſtic buſineſs, without the light of candles. In ſome places, the darkneſs was ſo great, that perſons could not ſee to read common print in the open air, for ſeveral hours together: but I believe this was not generally the caſe. The *extent* of this darkneſs was very remarkable. Our intelligence, in this reſpect, is not ſo particular as I could wiſh: but from the accounts that have been received, it ſeems to have extended all over the *New-England* ſtates. It was obſerved as far eaſt as *Falmouth*.—To the weſtward, we hear of its reaching to the furtheſt parts of *Connecticut*, and *Albany*.—To the ſouthward, it was obſerved all along the ſea-coaſts:—and to the north, as far as our ſettlements extend. It is probable it extended much beyond theſe limits, in ſome directions: but the exact boundaries cannot be aſcertained by any obſervations that I have been able to collect. With regard to its *duration*, it continued in this place at leaſt fourteen hours: but it is probable this was not exactly the ſame in different parts of the country. The *appearance* and *effects* were ſuch as tended to make the proſpect extremely dull and gloomy. Candles were lighted up in the houſes;—the birds having ſung their evening ſongs, diſappeared, and became ſilent;—the fowls retired to rooſt;—the cocks were crowing all around, as at break of day;—objects could not be diſtinguiſhed but at a very little diſtance; and every thing bore the appearance and gloom of night.

Such were the general appearances or phenomena of this extraordinary darkneſs. I ſhall now mention ſuch particular obſervations as I have been able to collect, which were either made on this phenomenon, or ſeem to relate to it.

With regard to the ſtate of the atmoſphere preceding this uncommon darkneſs, it was univerſally obſerved for ſeveral days before, that the air appeared to be full of ſmoke and vapour. The ſun and the moon appeared remarkably red in their colour, and diveſted of their brightneſs and lucid appearance: and this obſcuration increaſed as they approached nearer to the horizon. This was obſerved to be the caſe in almoſt all parts of the *New-England* ſtates, for four or five days preceding the 19th of May. The winds had been variable; but chiefly from the S. W. and N. E. The thermometer from 40° to 55°. The barometer rather high for this part of *America*,—from 29 inches 80, to 30 inches 50. The weather had been fair and cool for the ſeaſon.

As to the ſtate of the atmoſphere when the darkneſs came on, it was obſervable, that the weight or gravity of it was gradually decreaſing the bigger part of the day. This may be inferred from the obſervations that were made in this place by the Rev. Profeſſor *Wiggleſworth*, and Mr. *Gannett*. At 12$^{h.}$ they found the mercury in the barometer ſtood at 29 inches 70. At 12$^{h.}$ 30′, the mercury had fallen the $\frac{1}{100}$ part of an inch. At 1$^{h.}$ it was at 29 inches 67. At 3$^{h.}$ it was at 29 inches 65. At 8$^{h.}$ 8′ it was at 29 inches 64. I made a courſe of barometrical obſervations ſimilar to theſe, at the ſame time, in a different part of the ſtate. I was then at *Bradford*, about thirty miles north of this place, nearly under the ſame meridian, or rather a little to the eaſt. At 6$^{h.}$ A. M. I found the mercury in the barometer 29 inches 82. As ſoon as the darkneſs began to appear uncommon, I obſerved the barometer again, and found the mercury at 29 inches 68: this was at 10$^{h.}$ 20′. At 10$^{h.}$ 45′, the darkneſs aroſe to its greateſt degree in that part of the country; and the mercury was then at 29 inches 67. The darkneſs

neſs continued in the ſame degree for an hour and an half. At $12^{h.}$ 15′, the mercury had fallen to 29 inches 65; and in a few minutes after this, the darkneſs began to abate. The mercury remained in this ſtate until evening, without any ſenſible alteration. At $8^{h.}$ 30′, it ſeemed to have fallen a little; but ſo ſmall was the alteration, that it was attended with ſome uncertainty; nor could I preceive that it ſtood any lower at $11^{h.}$ 30′.

Both theſe barometers appear to be very good inſtruments. That uſed in this place was made by *Champney*: that which I uſed was made by *Nairne*: and they may both be depended on as to the accuracy of their conſtruction. It may, however, be proper to obſerve, that the houſe where I made my obſervations, ſtood at leaſt forty or fifty feet higher than that in which the obſervations were made here.

And from theſe obſervations it is certain, that on the day when the darkneſs took place, the weight or gravity of the atmoſphere was gradually decreaſing through the whole day.*

The colour of objects that day, was alſo worthy of remark. It is mentioned, in the obſervations made by the gentlemen here, that "the complexion of the clouds was compounded of a faint red, yellow, and brown: and that, during the darkneſs, objects, which commonly appear green, were of the deepeſt green, verging to blue; and that thoſe which appear white, were highly tinged with yellow." Much the ſame obſervation was pretty generally made. Almoſt every object appeared to me to be tinged with yellow rather than with any other

* *Farenheit's* thermometer, at *Bradford*, at 6^{h}. A. M. was at 39°. At 12^{h}. it ſtood at 51°. At 9^{h}. P. M. it was at 46°.—At *Cambridge*, at 12^{h}. it was at $51\frac{1}{2}$°. At 3^{h}. P. M. it ſtood at 51°.

other colour. This I found to be the case with every thing I held up to view, whether near, or remote from the eye.

Another thing that deserves our attention is, the nature and appearance of the vapours that were then in the atmosphere. Early in the morning, the weather was cloudy: the sun was but just visible through the clouds, and appeared of a deep red, as it had for several days before. In most places thunder was heard several times in the morning. The clouds soon began to rise from the S. W. with a gentle breeze; and there were several small showers before eight o'clock: and in some places there were showers at other times, throughout the day. The water that fell was found to have an uncommon appearance, being thick, dark and sooty. A gentleman, who was then at *Ipswich*, observes, that "he found the people much surprized with the strange appearance and smell of the rain-water which they had saved in tubs. Upon examining the water, I found (says he) a light scum over it, which rubbing between my thumb and finger, I found to be nothing but the black ashes of burnt leaves: the water gave the same strong sooty smell which we had observed in the air." The same appearance was observed in many other places: and it was very remarkable on *Merrimack-River*. Large quantities of scum, or black ashes, were found floating upon the surface of the water, that day. In the night, the wind veered round to the N. E. and drove it towards the south shore. When the tide fell, it lay along the shore at the width of four or five inches. This I found to be the case for five or six miles;—and probably it was the case for many more. I examined a considerable quantity of this matter; and in taste, colour and smell, it very plainly appeared to be nothing more than what the gentleman observed at *Ipswich*,—

wich,—the black aſhes of burnt leaves, without any ſulphureous, or other mixtures.*

Being apprehenſive whether there was not ſome uncommon matter in the air that day, I put out ſeveral ſheets of clean paper in the air and rain. When they had been out four or five hours, I dried them by the fire. They were much ſullied, and became dark in their colour; and felt as if they had been rubbed with oil or greaſe. But upon burning them, there was not any appearance of ſulphureous or nitrous particles.

The motion and ſituation of the vapours in the atmoſphere, was alſo worthy of notice. In moſt places it was very evident that the vapours were deſcending from the higher parts of the atmoſphere towards the ſurface of the earth. A gentleman, who was then at *Pepperrell*,† mentions a very curious obſervation, as to their *aſcent* and *ſituation*. "About nine o'clock (ſays he) in the morning, after a ſhower, the vapours roſe from the ſprings in the low lands, in great abundance. I took notice of one large column that aſcended with great rapidity, to a conſiderable height above the higheſt hills, and ſoon ſpread into a large cloud; then moved off a little to the weſtward. A ſecond cloud was formed in the ſame manner, from the ſame ſprings, but did not aſcend ſo high as the firſt: and a third was formed from the ſame places, in leſs than a quarter of an hour after the ſecond. About three quarters of an hour after nine o'clock, theſe clouds exhibited a very romantic appearance. The upper cloud appeared of a *rediſh* colour: the ſecond appeared,

* The ſame was obſerved at *Concord* and *Dover* in *New-Hampſhire*: at *Berwick*, and many other places in this ſtate.

† Mr. *Eames*, a Tutor in the Univerſity.

peared, in some places, *green*; in others, *blue*; and in others, of an *indigo* colour: the third cloud appeared almost *white*." One of the gentlemen who observed here, mentions a circumstance of somewhat a singular nature.—" While the darkness continued (says he) the clouds were in quick motion, interrupted, skirted one over another; so as apparently, and I suppose, really, to form a considerable number of *strata*: the lower *stratum* of an uniform height as far as visible;—that height conceived to be very small from the small extent of the visible horizon, and from this circumstance observed in the evening:—Being in the street, I saw a person with a lighted torch, which occasioned a reflection of a faint red light, similar to a faint Aurora Borealis, at a small height above my head. The height at which the reflection appeared to be made, was not more than from twenty to thirty feet."—And it was generally remarked, that the hills might be seen at a distance in some directions, while the intermediate spaces were greatly obscured and darkened.

From these observations, it seems as if the vapours, in some places, were ascending; in most, descending; and in all, very near to the surface of the earth. To this we may add, that during the darkness, objects appeared to cast a shade in every direction: and that, in many places, there were several appearances or corruscations in the atmosphere, not unlike the *Aurora Borealis*: but I do not find that there were any uncommon appearances of the electric fire any where observed that day.*

Having

* In several accounts it was also mentioned, that a number of small birds were found suffocated by the vapour. " A number were found dead in several of the new towns, round the houses; and some flew into the houses, as I have been told by eye-witnesses." Extract of a letter from *Dover*, in *New-Hampshire*.

Having mentioned the phenomena, with ſuch obſervations upon them, as I have been able to collect, I ſhall now endeavour to account for the cauſe of this unuſual appearance.

From the obſervations that have been mentioned, we may conclude with much certainty, that the atmoſphere, on the 19th of May, was charged with an uncommon quantity of vapour. That this was the caſe, is evident from the large quantity of ſmoke and vapour that appeared in the atmoſphere for ſeveral days before; which was ſo great, as to darken the ſun and moon, and render all objects, at a diſtance, of a dull and very hazy appearance. It was alſo evident, from the deſcent of thoſe large quantities of ſoot, or black aſhes, which, through a long extent of country, were found mingled with the rain that fell, and floating on the ſurface of the waters. And the cauſe from whence the uncommon quantity of theſe vapours was derived, is eaſily aſcertained. It is well known, that in this part of *America*, it is cuſtomary to make large fires in the woods, for the purpoſe of clearing the lands in the new ſettlements. This was the caſe this ſpring, in a much greater degree than is common. In the county of *York*, in the weſtern parts of the ſtate of *New-Hampſhire*, in the weſtern parts of this ſtate, and in *Vermont*, uncommonly large and extenſive fires had been kept up. The people in the new towns had been employed in clearing up their lands this way, for two or three weeks before: and ſome large and extenſive fires had raged in the woods for ſeveral days before they could be extinguiſhed. In addition, therefore, to what ariſes from evaporation, and thoſe exhalations which are conſtant and natural, a much larger quantity of vapour aroſe from thoſe large and numerous fires, which extended all around our frontiers. As the weather had been clear, the

air heavy, and the winds ſmall and variable for ſeveral days; the vapours, inſtead of diſperſing, muſt have been riſing and conſtantly collecting in the air, until the atmoſphere became highly charged with an uncommon quantity of them.

A large quantity of the vapours, thus collected in the atmoſphere, on the 19th of May, were floating near the ſurface of the earth. Whereſoever the ſpecific gravity of any vapour is leſs than the ſpecific gravity of the air, by the laws of fluids, ſuch a vapour will aſcend in the air. Where the ſpecific gravity of a vapour, in the atmoſphere, is greater than that of the air, ſuch a vapour will deſcend: and where the ſpecific gravity of the vapour and air are the ſame, the vapour will then be at reſt,—floating or ſwimming in the atmoſphere, without aſcending or deſcending. From the barometrical obſervations it appears, that the weight or gravity of the atmoſphere was gradually growing leſs, from the morning of the 19th of May, until the evening. And hence the vapours, in moſt places, were deſcending from the higher parts of the atmoſphere, towards the ſurface of the earth. From the obſervation made at *Pepperrell*, it appears, that in ſome places the vapours were aſcending, until they aroſe to an height in which the air was of the ſame ſpecific gravity; where they inſtantly ſpread, and floated in the atmoſphere:—and this height was not much above the adjacent hills. From theſe obſervations, we are lead to conclude, that the place where the vapours were balanced, or became of the ſame ſpecific gravity as the air, muſt have been very near the ſurface of the earth. And hence we may obſerve,

That ſuch a large quantity of vapour, floating in the atmoſphere, near the ſurface of the earth, might be ſufficient to pro-

duce

duce all the phenomena that were obſerved May 19, 1780.— Thus the *direction* in which the darkneſs came on, would be determined by the direction of the wind; which accordingly was obſerved to be from the S. W. The *degree* of the darkneſs would depend on the denſity, colour, and ſituation of the clouds and vapour; and the manner in which they would tranſmit, reflect, refract, or abſorb the rays of light. The *extent* of the darkneſs would be as great as the extent of the vapour: and the *duration* of it would continue until the gravity of the air became ſo altered, that the vapours would change their ſituation, by an aſcent or deſcent. All which particulars will, I think, be found to agree very exactly with the obſervations that have been mentioned. Nor does the *effect* of the vapours, in darkening terreſtrial objects, when they lay near the ſurface of the earth, appear to have been greater than it was in darkening the ſun and moon, when their ſituation was higher in the atmoſphere.

Upon the whole, it is evident, that the atmoſphere was charged, in a high degree, with vapours; and that theſe vapours were of different denſities, and occupied different heights. By this means the rays of light falling upon them, muſt have ſuffered a variety of refractions and reflections; and thereby become weakened, abſorbed, or ſo far reflected, as not to fall upon objects on the earth in the uſual manner. And as the different vapours were adapted by their nature, ſituation, or denſity, to abſorb, or tranſmit, the different kind of rays, ſo the colours of objects would appear to be affected by the mixture and prevalency of thoſe rays that were tranſmitted through ſo uncommon a medium.

In what has been ſaid, I have endeavoured to explain what I take to be the cauſe of the late unuſual darkneſs. I would not, however, be underſtood to aſſert, that there could not be any other cauſes or circumſtances which might join to produce this unuſual appearance. Poſſibly there might be cauſes and circumſtances of this nature, of which we have no ſuſpicion. But as the uncommon quantity and ſituation of the vapours in the atmoſphere might be ſufficient to account for the phenomena, it appears to me to be unneceſſary to look out for other cauſes, or to go into a particular examination of the various conjectures that have been advanced upon this ſubject.

It may not be amiſs to obſerve, that ſuch appearances, and from the ſame cauſe, have been obſerved before, in this part of *America*. In the Philoſophical Tranſactions, N°. 423, there is an account of a remarkable darkneſs, which took place October 21, 1716, O. S. It is ſaid, "The day was ſo dark, that people were forced to light candles to eat their dinners by. Which could not be from any eclipſe, the ſolar eclipſe being the 4th of that month." This obſervation was made by Mr. *Robie*, a man of great ingenuity, and formerly a Tutor in the Unverſity: but there is nothing ſaid as to the cauſe, or any other particulars. Several perſons have informed me, that they remember an uncommon darkneſs in the year 1732, Auguſt 9, O. S. and which was afterwards found to be occaſioned by an uncommon fire in *Canada*. It is to be wiſhed, that we could find ſomething more particular upon this ſubject.

There was alſo a remarkable darkneſs at *Detroit*, October 19, 1762, much like that of May 19; of which we have this account, by the Rev. *James Stirling*, Phil. Tranſ. for 1763, vol. liii. p. 63. "Tueſday laſt, being the 19th inſt. (i. e. of

" October)

" October) we had almoſt total darkneſs for the moſt of the
" day. I got up at day break. About ten minutes after, I ob-
" ſerved it got no lighter than before. The ſame darkneſs con-
" tinued until nine o'clock, when it cleared up a little. We
" then, for the ſpace of about a quarter of an hour, ſaw the
" body of the ſun, which appeared as red as blood, and more
" than three times as large as uſual. The air, all this time,
" which was very denſe, was of a dirty yellowiſh colour. I
" was obliged to light candles to ſee to dine, at one o'clock,
" notwithſtanding the table was placed cloſe by two large win-
" dows. About three, the darkneſs became more horrible;
" which augmented until half paſt three, when the wind breez-
" ed up from the S. W. and brought on ſome drops of rain,
" or rather ſulphur, and dirt; for it appeared more like the
" latter than the former, both in ſmell and quality. I took a
" leaf of clean paper, and held it out in the rain, which ren-
" dered it black whenever the drops fell upon it; but, when
" held near the fire, turned to a yellow colour; and when
" burned, it fizzed on the paper like wet powder. During this
" ſhower, the air was almoſt ſuffocating with a ſtrong ſulphu-
" reous ſmell.—It cleared up a little after the rain.

" There were various conjectures about the cauſe of this na-
" tural incident. The *Indians*, and vulgar among the *French*,
" ſaid, that the *Engliſh*, which lately arrived from *Niagara* in
" the veſſel, had brought the plague with them. Others ima-
" gined, it might have been occaſioned by the burning of the
" woods: but I think it moſt probable, that it might have
" been occaſioned by the eruption of ſome volcano, or ſubter-
" raneous fire, whereby the ſulphureous matter may have been
" emitted in the air, and contained therein, until, meeting with

" ſome

" ſome watery clouds, it has fallen down together with the " rain."

We have another account of this phenomena, in a letter from an officer, who was then at *Detroit*, to a friend at *Wilmington*, in *Pennſylvania*. " The 19th of this month, (October, 1762) " was the moſt extraordinary dark day, perhaps, ever ſeen in " the world. At nine in the morning, it was ſcarce lighter " than at break of day, and ſo continued till about twelve " o'clock,—the air being very full of ſmoke, accompanied with " a ſtrong ſmell, as of wood, ſtraw, and other combuſtibles, " when burning. At half an hour after one, it was ſo dark " that we were obliged to light candles to dine by. At this " time it rained a little; with which fell a quantity of black " particles, like aſhes, as turned every thing it fell upon black. " Even the river (which is twice as wide as *Chriſtiana* in *Penn-* " *ſylvania*) was covered with black froth; which, when ſcum- " ed off the ſurface, reſembled the lather of ſoap, with this " difference, that it was (and as black as ink) more greaſy. At " ſeven in the evening, the air was more clear, and the diſagree- " able ſmell was now almoſt gone. We have ſince been in- " formed, by people who were twenty miles from hence that " day, that the darkneſs, rain, and ſmell, was the ſame with " them."

There does not appear to have been any thing to ſupport the conjecture of a *volcano, ſubterraneous fires*, and *ſulphureous matter*. In all other particulars, the phenomena agree to thoſe that were obſerved among us, and ſeem to be derived from the ſame cauſe.

Felix, qui potuit rerum cognoſcere cauſas,
Atque metus omnes et inexorabile fatum
Subjecit pedibus.——————

V. *An Account of the Effects of Lightning on two Houses in the City of* Philadelphia. *In a Letter from the Hon.* ARTHUR LEE, *Esq; F. A. A. to the Hon.* JAMES BOWDOIN, *L. L. D. Pres. A. A.*

Philadelphia, July 29, 1781.

SIR,

TWO houses, in this city, have been lately struck with lightning, attended with phenomena that are curious, and may be useful; I therefore flatter myself, that an account of them will be agreeable to your Society.

On the 26th June, 1781, about ten o'clock at night, a large house in Market-street, called Mrs. *House's*, occupied by several Members of Congress, was struck by lightning, which entered through the ceiling of the garret, leaving what appear exactly like two bullet-holes. It then glanced along the door, tracing its passage by a blackish line, in an oblique direction, to an iron hinge; and passing from the uppermost hinge to the lowest, pierced thro' the ceiling into the room below; where, meeting immediately with the bell-wire, it was conducted by it, through all the chambers down two stories, till it ended at the bell, which hung over a back door near the kitchen; and its conductor ending there, it split the door to pieces. From this bell there was a wire which should have gone to the street door, but was broke: yet where the bell-handle (which was iron) ended upon the frame of that door, the nearest pannel was split to pieces. It is therefore supposed, that this was a separate portion of the electrical fluid, which was attracted by the iron rod which formed the bell-handle out-side of the door.

The

The houſe was ſhingled, and one ſhingle appeared looſened. A man was in bed in the garret directly under where the fluid entered, and muſt have been ſmitten by it, had not the iron hinge drawn it from that direction to itſelf. The hinge was two feet from one hole, and two feet and an half from the other in an oblique direction. The angle, at the corner of the hinge neareſt the holes, was left very bright; and, probably, that angle operated as a point to attract and receive the electrical matter. The wire, in many places, was melted; and, dropping, burnt the floor. One of the gentlemen, who was in bed in one of the rooms, leaping out upon the floor, burnt the ſoles of his feet, where they touched the wire. To others, the wire ſeemed to be in flames, and a ſulphureous ſmell remained in the chambers. The houſe is higher than any that was near it, ſituated on the ſouth ſide of the ſtreet;—has no point, or conductor, fixt to it;—was ſtruck at the weſtern and eaſtern ends; and the back door, which communicated with the bell-wire, is on the ſouth ſide. The other that was ſtruck, was at the eaſtern end.

On the 8th of July, 178 , the wind being at the northward of weſt, but variable, the houſe of Dr. *Shippen*, jun. [Plate III. Fig. 1.] was alſo ſtruck, in a manner that will be beſt underſtood by the encloſed ſketch, or ground-ſection, [Fig. 2.] of the houſe; though, to comprehend it, we muſt ſuppoſe, that the courſe of the wire, repreſented by the dotted lines, is along the ceiling, inſtead of the floor, as is here repreſented. The traces of the lightning, that appear in the houſe, (for there are none outſide) are theſe.—At the place where the broken wire ends in the paſſage, and is coiled up at *k*, the plaiſter is beat off, about the ſize of a large hand expanded, to the brick wall, which is uninjured. Between the bells, *a* and *b*, the ceiling is raiſed and cracked, in a ſtraight direction,

rection, from one to the other, but not fallen off. At the front door, in the corner, about two feet from the floor, the plaiſter is broke off, as at *n*, in the other end of the paſſage: but there is an apparent trace of the lightning on the bricks, in a blueiſh mark. There is no communication between this and the wire, which runs along the ceiling over it ſixteen or ſeventeen feet diſtant; nor any iron near, except it be the back of the fire-place on the other ſide of the wall, oppoſite to where the plaiſter is beaten off. In the dining-room, the wire is melted from *o* to *p*, and again from *q* to *r*; all the remainder being entire, and the reſt of the wire, in the other parts of the houſe, and the outſide, uninjured. The pieces of wire that fell on the floor, burnt deep holes in it. The conductor being examined, was found to be in good order; but the point, which was copper, was melted ſo as to form a ſort of button; which had not that degree of brightneſs, which thoſe, ſkilled in the fuſion of copper, ſay this metal preſerves for ſome time after its having been melted. This effect upon the point appears, therefore, to be of an older date. The conductor is about half an inch diameter,—enters about two feet into the ground, and is fixt to the wall by ſix iron ſtaples; none of which are nearly oppoſite to the wire in the dining-room. Mrs. *Shippen* felt an electrical ſhock as ſhe ſtood in the paſſage up ſtairs, with her hand on an iron latch. Theſe are the facts;—and the electricians here differ in their opinions, about the manner of the electrical fluid's meeting with the bell-wire. Some think it deſcended through the conductor; but being in a greater quantity than the earth would immediately receive, part quitted the conductor, and paſſed through the wall to the wire neareſt the conductor. The wire being melted in that part, ſeems to lead to this opinion:

but it is alſo melted in a remoter part; which ſeems to ſhew, that it was owing to partial defects in the wire: and if the fluid had quitted the conductor, it would naturally have paſſed off by the ſtaples that enter the wall, and ſhewn its effects in various parts, as they directed. The other opinion is, that it was conducted down the wet roof of the kitchen, which is of ſhingles, unto the corner, where, at *d*, it met with the bell-wire on the outſide of the wall; when part went into the dining-room, and another part into the kitchen; and paſſing from the firſt bell to the ſecond, (which is about a foot from the firſt, while the third is between two and three feet off) and by its wire was conducted into the paſſage to the coil, at *k*, where it took to the wall, and paſſed away. The ſtroke at the front door, muſt have been from a ſeparate ſource: for it does not, on a minute examination, appear probable, that it penetrated through the wall of the dining-room at the corner, *o*, (where the crank of the bell-wire is faſtened to the wall by a ſmall iron nail, entering about two inches) and ſo from that, paſſed to the wire in the paſſage, which continues from thence to the front door. Not the leaſt ſign of injury appears upon the roof of the laundry; nor externally, upon any part of the houſe.

From theſe obſervations we may conclude, that the manner in which the bell-wires are diſtributed in a houſe, is of great moment; and that they ought always to be diſpoſed with a view to the poſſibility of their becoming conductors. From the plaiſter being deſtroyed, and the bricks uninjured, it would ſeem that brick is a conductor, and therefore carried off the fluid without any further effect. That the points of conductors ſhould be examined from time to time; becauſe, in the ſtate in which that of Dr. *Shippen's* houſe was found, and had probably

bably been for ſome time, it would by no means anſwer the end of putting it up. That a conductor on each corner, or on each chimney of a houſe, eſpecially if of any ſize, is neceſſary, to guard it compleatly.

A. LEE.

P. S. Suppoſing that the fluid came to the uppermoſt crank of the wire, at *d*, firſt, it would ſeem that it did not part with that wire, in any portion, to go to the other, which ran cloſe to it, and entered through the ſame holes; nor even to that which goes into the parlour, and is attached to it, but kept to the ſame wire till it ended; which is conformable to what we ſee in experiment.

A ſection of Dr. *Shippen's* houſe, which muſt be ſuppoſed to be that of the upper parts at the ceiling, in order to underſtand the courſe of the bell-wires, and the paſſage of the electrical fluid.

a, The bell in the kitchen, which anſwers to the parlour and dining-room, by the wire which pierces the kitchen wall at *d*, and runs outſide of the paſſage wall to that of the dining-room, which it pierces at *e*, and is continued to the chimney, ending at *f*.—The portions of it, between *o p*, and *q r*, having been melted by the electrical matter.

b, The bell which anſwers to the front door: but the wire was broken at *l*, and hung down upon the wall, ending in a coil at *k*. The bell *b*, is alineated with the bell *a*, and much nearer to it than the third.

c, The bell which anſwers to the bed-chambers up ſtairs, by the faint dotted line, which pierces the wall with the firſt wire;

 runs

runs outside with it, and is fixt in the wall, in the corner, by a crank, which is about three inches below that of the dining-room, or first wire; and when it has pierced the wall into the dining-room, at the corner, *e*, makes a short turn, and passes through the ceiling up to the chambers. At *g*, a wire goes off to the parlour.

n, The place where the plaister was beat off in the passage at the front door; as it was at the other end of the passage, directly under the coil, at *k*.

s, Suppose to be the roof of the kitchen, ending directly over, and about twelve feet above the crank of the wire, *d*.

VI. *An Account of the Effects of Lightning on a large Rock in* Gloucester. *In a Letter from the Rev.* ELI FORBES, *to to the Rev.* MANASSEH CUTLER, *F. A. A.*

Gloucester, *July* 3, 1783.

REVEREND SIR,

ON the 18th of March, 1782, we had a most severe clap of thunder, and its effects were most surprising. A large rock, of the contents of near ten feet square above ground, received the full weight of its shock. It struck the rock near the top, and made an impression like that of a cannon-ball. It broke off near twenty pounds of the solid stone, and cracked the remaining body in several directions, though not very deep. Then it ran down on the western side of the rock in three directions, or main branches,—each branch marking its path with a chalky colour, tinged with blue. The lightning so penetrated the solid stone, as to alter the texture of its parts, and change its colour an inch deep; which still remains on a large piece of the rock now by me. When these three branches reached the ground, they took different routs.——One, that seemed to contain the greatest quantity of the fluid, took its course northward, rending the ground, and throwing up cart-loads of earth when it met with large rocks. Some large rocks, whose surfaces were nearly on a plain with the earth, it passed over, with only marking its path, about an inch and an half wide, with the same colour as on the rock it struck first: then it entered the ground, and tore up the turf about an inch deep. At a rock in its way, which rose some inches above-ground, it divided itself into two equal branches, turning up the turf from the

the basis of the rock, till they met on the opposite side, and passed much the same course, till it came to another rock, not quite so high, nor of so wide a base. At this rock it entered the ground, and raised it from its bed about three inches, tho' it was of several tons weight; which was the last effects I could discover of it.

The second main branch, which seemed to contain the next greatest quantity, took its rout westward by a stone wall; on the north side of which was a bank of snow, about six inches deep, and which was now in a watery state. It followed this wall under the snow, rending and removing some of the foundation-stones, and undermining others. Though it passed chiefly on the north side of the wall, under the snow, yet it was not confined to that side; for it crossed under it several times, before it got to the distance of fifty yards. Then it divided itself into two branches; and one turned off southward, across a piece of grass-land, a little descending towards the south, about two rods; which brought it upon a plain, or level, with the ridge of a barn, which stood on a beach near the sea-side, about fifty rods distant from the above-said grass-plot. It entered at the west end, just below the peak,—passed on the under side of the ridge-pole to a king-post, where it again divided into two branches; one ran down the post like an engraver's tool, within four feet of the ground, where about one third part of the post was hewed off; and on the opposite side was a spike, which was just entered into the wood, and stood horizontal:—it passed round the post to the head of the spike;—passed over the head,—drilled a small hole,—returned along the spike to the post, and then, splintering it, continued its course to the ground, and no further traces appeared. The other branch continued its course

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on the ridge-pole to the end ;—ran down a principal to a corner poſt, which it puſhed down, rending the board which covered it. In its way to the ground it left the poſt, and paſſed over two iron bolts that hung a gate to the poſt, leaving a froſted tract on them ;—returned to the poſt again, and continued to the bottom, which reſted on a flat ſtone ; and then paſſed acroſs the beach, about ſix or eight rods, throwing up the ground and pebble-ſtones, till it came to the water's edge, and no further effects could be ſeen. The other branch, at the wall, continued its courſe by it, producing ſimilar effects as before it divided, until it came near a pond of water, when it entered the ground, and broke out near the water's edge, making a ſmall hole, and could be traced no further.

The third main branch, at the rock firſt ſtruck, bent its courſe eaſtward. In ſome places it plowed deep furrows in the earth,—throwing up large quantities of earth and ſtones, and threw ſome ſtones, of twenty pounds weight, to the diſtance of four rods. In other places, it only marked its path as a lambent flame, without removing the lighteſt bodies that lay in its way, continuing its courſe to a ſmall collection of water, and there ceaſed.

A number of perſons, within the circle of two hundred yards, very ſenſibly felt the ſhock. Thoſe that were abroad were thrown to the ground, and remained ſenſeleſs ſome minutes : thoſe that were in the adjacent houſes, felt an effect, or ſhock, like that of electricity ; by which ſome parts of the body ſuffered more than others. A young woman, who was leaning with her elbow againſt a jamb of a chimney, felt it ſtruck numb, and remained ſo for ſome hours ; and, when it began to recover, it was in very great pain. Another woman was ſetting with her

her feet upon a hearth, who felt a violent ſhock acroſs her legs; and her feet and about half way of her legs remained inſenſible for ſome time.

Thus, Sir, I have given you the particulars of the ſurpriſing operations of the lightning; and you may depend on all that I have related to be fact, as I critically examined the whole the next day, and made minutes of the ſame, while on the ſpot: And you may communicate as much of it as you pleaſe to your learned Society.

I am, Sir, &c.

ELI FORBES.

Rev. Mr. Cutler.

N. B. I have encloſed an imperfect ſketch, [Plate III. Fig. 3.] which may aſſiſt you in forming your ideas of the various courſes of the lightning.

Facing p. 256
Plate 3
Back view of Govr. Shippen's House
Fig. I
Fig. II
Parlour
Dining room
Pantry
Kitchen
Front door
Fig. III
Rock raised up 3 inc^s.
Rock passed round
Rock passed over
Stone thrown 4 rods of 20^d W^t.
1 The place struck
2 The cracks in the rock
3 The main branch
4 The second main branch
5 The third main branch
A
B
C
D
E

VII. *An Account of a very curious Appearance of the electrical Fluid, produced by raising an electrical Kite in the Time of a Thunder-shower. In a Letter from* LOAMMI BALDWIN, *Esq; F. A. A. to the Rev.* JOSEPH WILLARD, *President of the University at* Cambridge, *and V. Pres. A. A.*

Woburn, *May* 26, 1783.

REVEREND SIR,

IN July, 1771, I constructed an electrical kite; the stem of which was about four and an half feet long, and the breadth, at the extremities of the bow, about two feet: the under side was covered with silk. About eight or ten wires, of the size and length of worsted knitting-needles, ground at one of their ends to a sharp point, were, at their opposite ends, inserted into the stem, at equal distances, from one extremity to the other. A very small wire was placed along the stem, with a turn round each point: and each end of the wire, passing through the stem, was continued, entwined round the belly-band, until they met, and communicated with the main flying line, by which the kite was raised. This line was a small, hard cord, and was soaked in water, previous to raising the kite. I also prepared a silk line, in order to insulate the kite after I had raised it to the height intended.

My design was to make some experiments in the time of a thunder-shower, whenever a favourable opportunity should offer. A few days after, there appeared a very heavy thunder-shower rising from the N. W. attended with a violent wind, which was then only evident by the motions and convulsions of the clouds. Circumstances, by this time, became favourable for

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my deſigns, although it was yet calm where I was. I made ready my apparatus; and the wind freſhened up, and preſently blew a conſiderably hard gale. The higheſt verge of the riſing cloud was not yet elevated more than to the fifty-fifth or ſixtieth degree from the horizon, but attended with the moſt piercing ſhafts of lightning, and tremendous thunder that I had ever beheld or heard, at the ſame diſtance,—and the zenith ſtill ſerene. I adjuſted the lines of the kite as near as I could to the ſtrength and power of the wind, and ſoon raiſed it to the height of ſome lofty trees, which ſtood near my houſe, or perhaps ſomething higher, but I am ſure not much. By this time I diſcovered a rare medium of fire between my eyes and the kite.—I caſt my eyes towards the ground;—the ſame appearance was there.—I turned myſelf around;—the ſame appearance ſtill between me and every object I caſt my eyes upon.—I felt myſelf ſomewhat alarmed at the appearance. I ſtood, however, and reaſoned with myſelf upon the cauſe, for ſome time, but gained very little ſatisfaction,—the ſame fiery atmoſphere ſurrounded me, only more bright and apparent. I was about to diſcontinue my experiments for that time; but reaſon accuſed imagination with error; and ſuppoſing it might poſſibly be only fancy, not knowing the cauſe of ſuch an appearance, and feeling no very bad effects from it, I continued to raiſe the kite. The cloud had not yet quite obſcured the heavens over me, but appeared ſtill to be very highly, though unequally, charged with the electrical fluid; which, by gaining an equilibrium, cauſed an inceſſant rattling, as if the heavens were rending aſunder. All this time, the fiery atmoſphere was increaſing and extending itſelf, with ſome faint gentle flaſhings; but with no other effects upon me than a general weakneſs in my joints and limbs, and a kind

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of liſtleſs feeling: all which might poſſibly be only the effect of ſurpriſe:—however, it was ſufficient to diſcourage me from any further attempts at that time. I drew in the kite, and retired into a ſhop, which ſtood near my houſe, and continued there until the ſhower (which was very ſevere) was over, and then went into my houſe, where I found my parents and family vaſtly more ſurpriſed than I had been myſelf; who, after expreſſing their aſtoniſhment, informed me, that I appeared to them (during the time I was raiſing the kite) to be in the midſt of a large bright flame of fire, attended with flaſhings; and expected, every moment, to ſee me fall a ſacrifice to the flame. The ſame was obſerved by ſome of my neighbours, who lived near the place where I ſtood.

I ſhall make no remarks, at this time, upon the cauſe; but leave it for the preſent to the conſideration of the learned.

I am, Sir, &c.

LOAMMI BALDWIN.

The Rev. Preſident Willard, *Correſponding-Secretary of the* American *Academy of Arts and Sciences.*

VIII. *Obſervations and Conjectures on the Earthquakes of* New-England. *By Profeſſor* WILLIAMS, *F. A. A.*

IN looking over ſome of the hiſtories of *New-England*, I obſerved, that the religious turn of mind which diſtinguiſhed the firſt planters of *New-England*, had lead them to take notice of all the Earthquakes which happened in the country, after their arrival. Several of them ſeemed to be pretty well deſcribed; and in ſome of their phenomena, there ſeemed to be an agreement. As ſeveral of theſe accounts were contained in writings but little known, I thought it might be of ſome ſervice to philoſophy, if a particular account of them could be collected. This is what I have attempted in the following treatiſe. In the *firſt part* of it, I have ſet down the moſt particular accounts I could find of their phenomena. The *ſecond* contains obſervations and remarks upon their agreement and operations. In the *third*, conjectures are propoſed as to their cauſes: and in the *fourth*, ſome general reflections are added as to their nature, uſe, and effects.

The moſt likely way to come to the knowledge of their cauſes, is to obſerve all the phenomena that attend them. That the reader might have a true account of theſe phenomena, it was my endeavour, in the accounts and obſervations, to note all the particulars that ſeemed to relate to them, however minute or trivial ſome of them might appear. With this view, I conſulted all the accounts I could find. From ſeveral of them, (the Honourable Profeſſor *Winthrop's* Lectures on Earthquakes, in particular) I have received much help. Others referred to authors of which I could not have the advantage of a peruſal. That gentlemen of ſcience might have it in their power to ex-

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amine with what fidelity and care the accounts are drawn up, or how far they might be depended upon, I have constantly referred to the authors from which they are taken. Some of the accounts, I am sensible, are greatly imperfect: as all our conjectures, theories, and reasonings, must depend on the accounts, it is much to be wished, that something more accurate and perfect, as to several of them, might be transmitted down to posterity.

What is proposed as to their *causes*, will be judged of, by the degree of probability and evidence with which it is attended. In all philosophical hypotheses, a writer is in danger of making more of his subject than will bear a strict examination. I have found some difficulty in guarding against this: and whether, at last, I have not carried *conjectures*, in some things, too far, the reader must judge for himself. After all, the revolutions of time will afford the surest proof of the truth or errors contained in the following pages. I would, therefore, make it my request to posterity, to note, with care and accuracy, the phenomena that may attend any future earthquakes in *New-England*; that, if what is here advanced as to their causes, shall be found to be true, it may be confirmed; but, if found to be false, it may meet with the fate of other errors, and be rejected. The cause of truth and science, is of infinitely more importance, than any of our schemes or conjectures: and this is what I wish may prevail, in all countries, and in all ages.

An HISTORICAL ACCOUNT of the EARTHQUAKES of NEW-ENGLAND.

THE *English* arrived at *Plimouth*, in *New-England*, November 11, 1628. The *first* earthquake that happened in the country after their arrival, was on July 2, 1638, O. S. The *manner* of its approach, and the *violence* to which it arose, are pretty well described in accounts which are yet existing. It is described as having been preceded with a rumbling noise, or low murmur, like remote thunder. As the noise approached, the earth began to quake, till the shock arose to such a violence, as to throw down the pewter from the shelves, stone walls, and the tops of several chimnies; and, in some places, made it difficult for people to avoid falling. The *course* of this earthquake, in some of the accounts, is described as being from the westward to the eastward. In others, it is represented as coming from the northward, and going off southward. It is not likely any great care, or accuracy, was employed, to determine what particular point of the compass the roar or shake came from; but only to fix it to that, which was judged to be the nearest cardinal point, which some thought was the west, others the north. It is most probable, therefore, that a middle course, from about north-west to south-east, was the true; as this will best agree with, and reconcile all the other accounts that were given of its course. To what *extent* this earthquake reached, on any point of the compass, we have no way to determine.— It is said in general, that it reached far into the land, and was observed by the *Indians* much beyond any of the *English* settlements, which then were but of small extent. And also, that some vessels, which were near the coast, were shaken by it.

In about half an hour there was another ſhock, but not ſo long or ſtrong as the former.*

Omitting a ſhock on October 29, 1653, as too ſmall to occaſion a general notice, the next memorable earthquake, was in 1658. In all the ancient hiſtories, this is mentioned as a *great* earthquake. But I cannot find any account of the month, day, violence, courſe, effects, extent, or any other particulars of it.

On January 26, 1663, O. S. "at the ſhutting in of the evening,"† another memorable earthquake ſhook *New-England*. From the general expreſſions the writers who ſpeak of it uſe, it ſeems to have been one of the *greateſt* this country ever felt. It is repreſented as being preceded with a great noiſe and roar. Mention is made of the houſes rocking, the pewter falling from the ſhelves, the tops of ſeveral chimnies falling in, the inhabitants running out into the ſtreets, paſſengers being unable to keep on their feet, &c. As to its *courſe*, *duration*, or *extent*, nothing is to be found in any of the *New-England* writers. But they are well deſcribed in the accounts that were given of this earthquake in *Canada*.

At the ſame time, February 5, 1663, N. S. "about half an hour after five in the evening," a moſt terrible earthquake began there. The heavens being very ſerene, there was ſuddenly heard a roar, like that of a great fire. Immediately the buildings were ſhaken with amazing violence. The doors opened and ſhut of themſelves, with a fearful clattering. The bells rang, without being touched. The walls ſplit aſunder. The floors ſeparated, and fell down. The fields put on the appearance of precipices,

* Vide *Johnſon's*, *Hubbard's*, and *Morton's* accounts of this earthquake.

† *Morton.*

precipices; and the mountains seemed to be moving out of their places: and amidst the universal crash which took place, most kinds of animals sent forth fearful cries and howlings.

The *duration* of this earthquake was very uncommon. The first shock continued half an hour before it was over; but it began to abate in about a quarter of an hour after it first began. The same day, about eight o'clock in the evening, there was a second shock, equally violent as the first; and in the space of half and hour, there were two others. The next day, about three hours from the morning, there was a violent shock, which lasted a long time: and the next night, some counted thirty-two shocks; of which, many were violent.—Nor did these earthquakes cease until the July following.

New-England and *New-York* were shaken with no less violence than the *French* country. And, throughout an *extent* of three hundred leagues from east to west, and more than one hundred and fifty from north to south, the earth, the rivers, and the banks of the sea, were shaken with the same violence. The shocks sometimes came on suddenly; at other times by degrees. Some seemed to be directed upwards; others were attended with an undulatory motion.—And throughout the vast extent of country to which they reached, they seemed to resemble the motions of an intermitting pulse, with irregular returns; and which commenced through the whole at the same hour.

This earthquake was attended with some remarkable *effects*. Many fountains and small rivers were dried up. In others, the water became sulphureous: and in some, the channel in which they ran before, was so altered that it could not be distinguished. Many trees were torn up, and thrown to a considerable distance.

And

And ſome mountains appeared to be much broken and moved. Half way between *Tadouſſac* and *Quebec*, two mountains were ſhaken down: and the earth thus thrown down, formed a point of land, which extended half a quarter of a league into the river *St. Lawrence.* The iſland *Aux Coudres*, became larger than it was before: and the channel in the river, became much altered.*

From theſe accounts it is evident, that *Canada* was the chief ſeat of theſe concuſſions: and of conſequence, as it proceeded from thoſe parts, its *courſe* muſt have been from ſome point between the weſt and north; probably much the ſame with that of 1638.

After an interval of ſixty-four years, (in which there had been ſeveral ſmall ſhocks, but none ſo violent as to occaſion a very long remembrance†) there came on another very memorable one, October 29, 1727, O. S. About $10^{h.} 40'$, P. M. in a very clear air and ſerene ſky, when every thing ſeemed to be in a moſt perfect calm and tranquility, a heavy rumbling noiſe was heard. At firſt it ſeemed to be at a diſtance, but increaſed as it came near, till it was thought equal to the roar of a blazing chimney, and at laſt to the rattling of carriages, driving fiercely on pavements. In about half a minute from the time the report was firſt heard, the earthquake came on. It

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* Vide *Frezier's Voyage*, p. 210, 211. Journal des *Scavans Mai.* 1678. *Charlevoix's* Hiſtoire de la *Nouvelle France.*

† In Phil. Tranſ. No. 437, mention is made of earthquakes in 1660, 1665, 1668 and 1669. Dr. *Mather* ſpeaks of earthquakes in 1670 and in 1705. There was another in 1720, on January 8. But theſe, with ſome others, having been too ſmall to occaſion a general notice, and being only mentioned without any particular account of them, are paſſed by, as not affording us any light with regard to the nature, cauſe, or effects of theſe phenomena.

was obſerved by thoſe that were abroad, that as the ſhake paſſed under them, the ſurface of the earth ſenſibly roſe up, and then ſunk down again; which muſt have produced an *undulation* of the earth, or a motion like that of a wave, both perpendicular and horizontal; firſt riſing in a perpendicular direction, and as it ſubſided, ſpreading itſelf in a horizontal direction all around. The nature, therefore, or *kind* of the *motion*, was *undulatory*. The *violence* of the ſhock, like that of the other great earthquakes, was ſuch as to cauſe the houſes to ſhake and rock, as if they were falling to pieces. The doors, windows, and movables, made a fearful clattering. The pewter and china were thrown from their ſhelves. Stone walls, and the tops of ſeveral chimnies were ſhaken down. In ſome places, the doors were unlatched and burſt open, and people in great danger of falling. There were various opinions as to the *duration* of this earthquake. The moſt probable is, that the ſhake began about half a minute after the roar was firſt heard, and roſe to its greateſt height in about a minute more; and was about half a minute in going off. Whence, the *duration* may be ſuppoſed to have been about two minutes. It was very generally agreed, that the *courſe* of this earthquake was from north-weſt to ſouth-eaſt. "The noiſe and ſhakes, it is ſaid, ſeemed to come from the "north-weſtward, and to go off ſouth-eaſterly; and ſo the "houſes ſeemed to reel." This account of its courſe, was confirmed by all the others, one or two excepted, which differ ſo much from one another, that nothing can be determined from them. With regard to the *limits* of this earthquake, it extended from the river *Delaware*, in *Pennſylvania*, ſouth-weſt, to *Kennebeck*, north-eaſt. At both theſe places it was ſenſibly felt, though the ſhake was but ſmall. Its extent, therefore,

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from ſouth-weſt to north-eaſt, muſt at leaſt have been ſeven hundred miles, and probably many more. As to its other limit, from north-weſt to ſouth-eaſt, we have no way to determine how far it extended. It was felt by veſſels at ſea, and in the moſt remote weſterly ſettlements. As it came from the unknown parts, between the weſt and north, and paſſed off into the ſea, it is probable it might run ſome thouſand miles in ſuch a courſe.

There were ſeveral *effects* attending this earthquake, which ſeem worthy of remark. Beſides what is common, as to the throwing down pewter, fences, &c. it was obſerved, that ſeveral ſprings of water, and wells, that were never known to be dry or frozen, were ſunk far down into the earth. Some were dried up. The quality of the water mended in ſome, and ſo altered in others as to freeze in moderate weather. Some ſpots of firm dry ſoil, became perfect quagmires; and others, that were full of mire and water before, became more dry. The centre of this earthquake, or place of greateſt violence, ſeems to have been at *Newbury*, a town which lies at the mouth of *Merrimack-River*. " There, (according to Dr. *Colman's* account) " the earth opened, and threw up ſeveral loads of a fine " ſand and aſhes, mixt with ſome ſmall remains of ſulphur; " ſo that, taking up ſome of it between the fingers, and dropping it into a chaffing-diſh of bright coals, in a dark place, " once in three times the blue flame of the ſulphur would " plainly ariſe, and yield a very ſmall ſcent. By this it ſeems " evident, that it was a ſulphureous blaſt which burſt open the " ground, and threw up the calcined bituminous earth."* Con-

 cerning

* Phil. Tranſ. No. 409. What is here ſaid of its being a ſulphureous blaſt, ſeems to be confirmed by the account which Mr. *Dudley* ſent to the Royal Society, in which

cerning this earth which was thrown up, the Rev. Mr. *Lowel*, minister in *Newbury*, mentions an uncommon circumstance. "One thing (says he) I may add, which is very remarkable, "and which may be depended on: that about the middle of "April, that fine sand, which was thrown up in several places "in this parish, at the first great shock, October 29, had a very "offensive stench; nay, was more nauseous than a putrifying "corps; yet, in a very little while after it had no smell at all. "How long it was before it begun to have this stench I am "not certain. I know it had it not at first: and, I believe, it "was covered with snow till a little while before.—There is no "smell now."* These accounts refer to matters so easy to be known, that there is no room to suspect that the authors (both gentlemen of a philosophic taste, as well as of eminence in their particular professions) could be mistaken. And it seems highly probable, from their observations, that the sand which was thrown out by the earthquake, contained some very noxious, ill-scented vapour, or effluvia; which, so long as there was nothing to confine it, passed away in quantities too small to be perceptible to the senses: but when it was kept together by the snow, gathered in such quantities as strongly to infect the air, when the melting of the snow gave it liberty to evaporate freely.

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which he says, "A clergyman in a town about twenty miles from *Boston* assured "him, that immediately after the earthquake, there was such a stink, or strong "smell of sulphur, that the family could scarce bear to be in the house for a considerable time that night. The like is also confirmed from other places. Persons "of credit do also affirm, that just before, or in the time of the earthquake, they "perceived flashes of light." Phil. Transf. No. 437.

* Letter to Dr. *Colman*. Phil. Transf. No. 409.

Some *phenomena* were obſerved a few days before this earthquake, which deſerve our notice, as having, probably, ſome *connection* with its approach. The Rev. Mr. *Allin*, then miniſter of *Brooklyn*, took notice of an uncommon alteration in the water of ſome wells. "About three days (ſays he) before "the earthquake, there was perceived, an ill-ſtinking ſmell in "the water of ſeveral wells. Not thinking of the proper cauſe, "ſome ſearched their wells, but found nothing that might thus "infect them. The ſcent was ſo ſtrong and offenſive, that for "about eight or ten days they entirely omitted uſing it. In "the deepeſt of theſe wells, which was about thirty-ſix feet, "the water was turned to a brimſtone colour, but had nothing "of the ſmell; and was thick like *puddle-water*."§ We have this account confirmed by Mr. *Dudley*.—"A neighbour of his "that had a well thirty-ſix feet deep, about three days before "the earthquake, was ſurpriſed to find his water, that uſed to "be very ſweet and limpid, ſtink to that degree that they could "make no uſe of it, nor ſcarce bear the houſe when it was "brought in; and imagining that ſome carrion was got into "the well, he ſearched the bottom, but found it clear and good, "though the colour of the water was turned wheyiſh, or pale. "In about ſeven days after the earthquake, the water began to "mend; and in three days more, it returned to its former "ſweetneſs and colour."* And juſt before the earthquake began, ſeveral wells were found to have no water in them, which had great quantities before and after. To whatever cauſe the alterations in theſe wells be aſcribed, it can hardly be thought but that they had ſome *connection* with the earthquake, which in

§ Account of the earthquake of 1727, by Mr. *Allin*.

* Phil. Tranſ. No. 437.

in a few days ran through the whole country. Several ſhocks were felt in the northern parts of *New-England*, for ſome months after that of October 29 : but they were generally ſmall and of a ſhort duration.*

In 1732, there was an earthquake, which, though ſmall, was of a conſiderable extent. It came on September 5, O. S. at about 11^h. A. M. being attended with a rumbling noiſe ; and was of ſuch *violence* as to occaſion a conſiderable jarring of the houſes. The *duration* of it, was not more than ten or fifteen ſeconds. This earthquake was much more evident at *Montreal* in *Canada*, than it was in any part of *New-England* ; being attended with conſiderable damage there. As this was the chief ſeat of it, it ſeems to have come from thence, in a *northweſterly courſe*, to *New-England*. Its *extent*, from ſouth-weſt to north-eaſt, was equal to that of moſt of the earthquakes that have been in the country ; being felt from *Maryland* to the *northeaſterly* parts of *New-England* : and from north-weſt to ſouth-eaſt, it reached from *Montreal*, and probably from many miles beyond it, to the ſea-coaſt.||

From the year 1732, though there had been ſome ſmall ſhocks, there was none that occaſioned a general notice, till 1744. That year, on June 3, O. S. a fair and hot day, there was an earthquake, ſo conſiderable, as to be generally felt thro' the province. It began a few minutes after 10^h. A. M. being preceded

* The account of this earthquake is collected from the printed accounts of it in the Philoſophical Tranſactions, and by ſeveral of the *New-England* miniſters.

|| Vide Phil. Tranſ. No. 429, and for 1757, p. 13, and alſo Profeſſor *Kalm's* travels, vol. i. p. 44, 2d edit. *London*. On February 6, 1737, at 4¼ P. M. and December 7, a little before eleven at night, ſmall earthquakes were felt at *Boſton* : but no particulars are mentioned as to their phenomena.

preceded with a very loud report; and is ſaid to have roſe to ſuch a *violence*, as to ſhake down ſome bricks from the tops of ſome chimnies, and alſo ſome pieces of ſtone wall. The *courſe* of this earthquake is ſaid, by ſome that remember it, to have been from the *weſtward* to the *eaſtward*. As to other particulars I can find no account.†

The next earthquake, that ſhook the whole country, was in the year 1755. November 18, N. S. at $4^{h.}$ 11′ 35″,‡ in a calm, ſerene and pleaſant night, came on the moſt violent ſhock of an earthquake that was ever known in *New-England*. The firſt thing obſervable, was that rumbling noiſe, or roar, which as a ſound *ſui generis*, ſeemed a prelude to an earthquake. In about half a minute, the ſurface of the earth ſeemed to be ſuddenly raiſed up; and, in ſubſiding, was thrown into a univerſal trembling, or a very quick, jarring, vibratory motion, which acted in an horizontal direction. This motion continued for about a quarter of a minute, and then abated for three or four ſeconds. Then, all at once, came on a violent, prodigious ſhock, as ſuddenly, to appearance, as a thunder-clap breaking upon

† Phil. Tranſ. for 1757, p. 14, and *American* Mag. for 1744.

‡ The beginning of this earthquake was determined to all the exactneſs that could be deſired, by the following accident.—Profeſſor *Winthrop* at *Cambridge*, ſome time before, having uſed a pretty long glaſs tube, in a particular experiment, ſhut it up in his clock-caſe, for ſecurity. This tube, ſtanding nearly perpendicular, muſt have been overſet by the firſt ſhock, which made it impoſſible for the pendulum to make any oſcillation, after the tube had ſtruck againſt it. The clock ſtopped at the time mentioned above. Being a very good one, and having been adjuſted by a meridian line, the preceding noon, it muſt have pointed out the beginning of the earthquake to a great preciſion. Had the time been as accurately determined at any other diſtant place, the velocity of its motion might have been determined to great exactneſs.

upon a houſe, and attended with a great noiſe. This ſudden and great ſhock began with the ſame *kind* of motion; and was immediately ſucceeded by quick and violent concuſſions, jerks and wrenches, attended "with an undulatory, waving motion of the whole ſurface of the ground, not unlike the ſhaking and quaking of a very large bogg." After this great ſhock had been gradually declining and going off, near half a minute, there was a ſenſible revival of it, though of ſhort continuance; and ſo all by degrees became ſtill and quiet again.

The *violence* of this earthquake was the greateſt of any we have ever had in the country. "In *Boſton*, beſides the throwing down of glaſs, pewter, and other movables in the houſes, about an hundred chimnies were, in a manner, levelled with the roofs of the houſes; and about fifteen hundred ſhattered, and thrown down in part. Some were broken off ſeveral feet below the top; and by the ſuddenneſs and violence of the jerks, canted horizontally an inch or two over, ſo as to ſtand very dangerouſly. Some others, thus broken off, were turned round ſeveral points of the compaſs, as with a circular motion. The roofs of ſome houſes were quite broken in by the fall of chimnies. The ends of about twelve or fifteen brick buildings were thrown down, from the top to the eaves of the houſes. Many clocks were ſtopped. The vane upon the public market-houſe was thrown down;—the wooden ſpindle, which ſupported it, being broken off at a place where it was five inches in diameter, and ten feet in height; and which had ſtood the moſt violent guſts of wind. A new vane, upon one of the churches in the town, was bent at the ſpindle, two or three points of the compaſs: and a diſtiller's ciſtern, made of plank, almoſt new, and very ſtrongly put together, was burſt to pieces, by the agitation of the

the liquour in it; which was thrown out with ſuch force, as to break down one whole ſide of the ſhed that defended the the ciſtern from the weather; as alſo to ſtave off a board or two from a fence, at the diſtance of eight or ten feet from it." Much the ſame things were obſerved in the country. At *Springfield*, a town diſtant about eighty miles in a weſterly line from *Boſton*, a ſpindle on one of their churches, was bent to a right-angle.—And through the whole province, much damage was done by the throwing down of ſtone fences, cellar walls, chimnies, and the like. Theſe things may ſerve to give us pretty juſt ideas of its *violence:* but it is to be obſerved, that the violence of the ſhock was different in different places; and not exactly the ſame in towns contiguous to one another; or indeed in all the parts of the ſame town.

There has been no earthquake in the country, whoſe *duration* was determined with ſo much accuracy as was that of this. Profeſſor *Winthrop* at *Cambridge*, the day before, had adjuſted his clock and watch by a meridian line. His clock was ſtopped at $4^{h.}\ 11'\ 35''$. Being awaked by the earthquake, he aroſe, and looking upon his watch, found it to be fifteen minutes after four. The jarring continued about a minute after this. The next day the watch was found to have kept time very exactly. So that the *duration* of the earthquake, taking in the whole of the time from the firſt agitation of the earth, till it became perfectly quiet, was very nearly four and an half minutes; though the violence of the ſhock did not laſt half ſo long. This obſervation of its duration at *Cambridge*, agreed pretty well with ſome of the ſame kind made at *Boſton*, by gentlemen who were up, and looked upon their watches when it began and ended.

In other places, its duration might be different, according to the different violence of the ſhock.

By the accounts of thoſe who were in the commons and open places, when the earthquake began, the *courſe* of it was nearly from north weſt to ſouth-eaſt. It was almoſt univerſally agreed, that the noiſe and ſhakes ſeemed to paſs in that direction: and thoſe things which were in ſuch a ſituation as that they might have been thrown indifferently to any point of the compaſs, pretty generally lay in that direction.

The *extent* of this earthquake, was traced to a great diſtance. On the ſouth-weſt, it reached as far as *Cheſapeake-Bay* in *Maryland*: being felt on the eaſtern, but not on the weſtern ſide. To the north-eaſt, it was felt as far as *Halifax*. It is much more difficult to determine its weſtern or eaſtern limit.—It extended to all our back ſettlements;—was felt at *Lake George*, and probably many miles beyond: but at *Oſwego*, ſituate on the ſouth-eaſtern ſhore of *Lake Ontario*, and diſtant from *Boſton* about two hundred and fifty miles weſt-by-north, it was not felt at all. On the *Atlantic*, the ſhock was ſo great ſeventy leagues eaſt of *Cape Ann*, that the people on board a veſſel, in that longitude, thought they had run aground, or ſtruck upon a rock, till on ſounding they found they had more than fifty fathom water. By accounts, which were ſoon after received from the *Weſt-Indies*, it ſeems probable that the earthquake reached as far as thoſe iſlands; or, rather, paſſed by to the eaſtward of them. The account was, "That on the 18th of November, "about two o'clock in the afternoon, the ſea withdrew from "the harbour of *St. Martin's*, leaving the veſſels dry, and fiſh "on the banks, where there uſed to be three or four fathom "water: and it continued out a conſiderable time; ſo that the

" people retired to the high lands, fearing the consequence of
" its return: and when it came in, it arose six feet higher than
" usual, so as to overflow the low lands. There was no shock
" felt at the above time."

As this extraordinary motion of the sea happened about nine hours after the great shock was felt in *New-England*, it seems very likely to have been occasioned by the same convulsion of the earth. As this earthquake went off south-eastward into the *Atlantic*, it would pass considerably to the eastward of *St. Martin's*, which has about 18° of north latitude, with 62½° of west longitude. And this was the case at the island. There was no shock felt; but the motion of the sea was probably owing to a great agitation, raised at a considerable distance, in some part of the ocean, by the passage, or by an eruption of the earthquake, and from thence propagated to that island.— And what seems to be a confirmation of this, the length of time was no greater than what seems necessary for such a purpose. We cannot, indeed, state, with great accuracy, the *velocity* with which the earthquake moved: but yet it is very evident from its duration, and being preceded with a roar, that its motion was not very swift: and that of the waves, raised thereby, and propagated to the land, must have been much slower: both of which might easily take up nine hours in being propagated, and that in a circular direction, to such a distance as that of *Boston* and *St Martin's*. The *extent*, therefore, of this earthquake, from south-west to north-east, must have been about eight hundred miles: but from north-west to south-east, it reached at least nineteen hundred; and, perhaps, many more.

As the *effects* of this earthquake, great alterations were obſerved in the ſprings, wells and ponds of water. In ſome, the quality of the water was altered; in others, the quantity. New ſprings were opened; old ones dried up: the channel in many, was much changed; and the water in ſome was obſerved to boil up in an unuſual manner, for ſeveral days both before and after the earthquake. At *Pembroke*, *Scituate* and *Lancaſter*, there were chaſms made in the earth. At *Pembroke*, there were four or five of them; out of ſome of which, water iſſued, and many cart-loads of a fine, whitiſh and compreſſible ſort of ſand, was ſpewed.* Nor were its effects confined to the land;—ſeveral of the ſea-faring men agreed in their accounts, that almoſt immediately after the earthquake, large numbers of fiſh, of different ſorts, both great and ſmall, came up to the ſurface of the water,—ſome dead, and others dying. One of the fiſhing veſſels, at that time out upon the *Banks*, took up and brought in ſeveral quintals of theſe fiſh, which were found in large numbers, dead and dying, upon the ſurface of the ſea.†

There

* Speaking of this ſand, "By what I have heard," ſays Dr. *Mayhew*, "it was "of a ſulphureous nature." It is to be regretted, that no experiments were made with it, to determine, with certainty, whether this was the caſe or not.

† In phenomena, of whoſe cauſes we have ſo little knowledge, it is beſt to note every circumſtance however minute, and whether it ſeems to have much connection with the ſuppoſed cauſes or not; as we do not know but that they may be of uſe, when future obſervations come to be compared with them. For this reaſon, it may not be amiſs to ſubjoin to the above account, 1. That at the time of the earthquake, there was no alteration in the atmoſphere, as to its weight or temperature: the *barometer* and *thermometer* not undergoing any alteration. 2. A very great white froſt was obſerved in the morning, much larger than had been for ſeveral years. When it was melted, Profeſſor *Winthrop* meaſured it, and found that it covered the ground

There were ſeveral ſmall ſhocks ſoon after this of November 18.—One in about an hour and a quarter after the firſt, viz. at 5$^{h.}$ 29′. A ſecond, on November 22, at twenty-ſeven minutes after eight at night. A third, on December 19, at 10$^{h.}$ P. M. Their *violence* and *duration* was ſmall; their *courſe*, much like that of the great ſhock; and their *extent*, ſuch as to be pretty generally felt through the country. Many others, but very ſmall, were felt in different parts of the *Maſſachuſetts* and *New-Hampſhire*, for ſeveral months after.

In 1757, there was another earthquake; which, tho' ſmall, was generally felt. I cannot find any printed account of this ſhock, and, therefore, can only mention ſome general obſervations, which I then made of it. It came on July 8, N. S. at about 2$^{h.}$ 20′, P. M. I was then in an open field, ſurrounded with pretty high hills, from ſouth-weſt to north-eaſt, in company with another perſon. The firſt thing we perceived, was a ſmall noiſe, like that of a riſing wind, which ſeemed to be at a great diſtance, but ſwiftly advancing. It was half a minute before there was any ſhock. This I inferred, not barely from any conjecture I was then able to make, which in a ſtate of ſurpriſe muſt be greatly uncertain, but from this circumſtance: after hearing the noiſe, we had enquired of each other what it could be; and as there was no ſhake, concluded it was not an earthquake, when immediately the ſhock came on. The converſation I well remember; and am certain it muſt have taken up half a minute, if not more. The *ſhock* itſelf was not of very great

ground $\frac{17}{1000}$ parts of an inch; which was almoſt double of any there had been for ſeven years before, and about five or ſix times as great as what is common in this country. The account of this earthquake is collected from Profeſſor *Winthrop's* Lecture, and account of it in Phil. Tranſ. for 1757, art. 1. and from Drs. *Chauncey's* and *Mayhew's* accounts of it.

great force; but seemed as though some small body was swiftly rolling along under the earth, which gently raised up that part of the surface that was over it, and then left it as gently to subside. The *course* of this earthquake appeared, to me, to be from the south-west to the north-east.—The noise and shake seemed very plainly to come on, and go off in that direction. I might, however, be deceived by the reflection of the sound from the adjacent hills, or from some other cause; for almost every one judged very differently of its *course*, that it was from north-west to south-east. This was the judgment of several men, who were at work together, in a large open field, where there was nothing to reflect the sound, or mislead the judgment. It is not impossible that both might have been right in their opinion; and this, upon the whole, I am apt to think was the case: that although its general *course* was from north-west to south-east, yet, in particular places, it left its general course, and run out to any point of the compass, as the subterraneous veins, or channels, might lead it. From the effects of other earthquakes, particularly that of turning and twisting chimnies, &c. it seems as though this had been the case with most of the large earthquakes we have had.

On the 12th of March, 1761, there was also a small earthquake. It began about $2^{h.}$ 30′ in the morning. It was said to have been divided into two shocks, with a small pause between, the last of which was the greatest. The weather was moderate, like that of the preceding day, and a perfect calm rested on the land and water; the horizon, all around, being covered with a whitish fog. The *duration* was supposed to be about half a minute. Happening in the night, and being too small to awake people in general, nothing can be collected with any certainty

as

as to its *course*. Its *extent*, however, was considerable; being felt not only in the *Massachusetts*, but in most of the adjoining states.

The same year, on November 1, about 8$^{h.}$ P. M. there was another earthquake. As usual, this was preceded with a heavy rumbling noise, which increased to a pretty loud report as it came near. There was a considerable interval of time between the roar and the shake. I endeavoured to make some computation of it by this method: just as the shock began to abate, I looked on my watch to note the time. The report I could hear for about half a minute after this. It is probable it was about as long in coming on, which would give half a minute between the noise and shake. The *shock* itself was of the *undulatory* kind; not *violent*, but sufficient to make the doors and windows jarr and clatter. Its *course* was very plainly from north-west to south-east, and it was pretty generally felt through the state, and in *New-Hampshire*.

In the years 1766, 1769, and 1771, there were small earthquakes. Their *courses* were all, I think, from about north-west to south-east. Their *durations* not more than twelve or fifteen seconds; and their *extent* but small. Not being attended with any thing remarkable, it is not necessary to write particular accounts of them.

November 29, 1783, about 10$^{h.}$ 54′, P. M. there was another small earthquake in *New-England*. Its *extent* was very considerable; being felt in *Pennsylvania*, *New-Jersey*, *New-York*, *Connecticut*, *Rhode-Island*, *Massachusetts* and *New-Hampshire*. At *Boston*, there was but one shock; and that was not violent enough to be generally perceived. At *Hartford* and *New-Haven*, in *Connecticut*, but one shock was perceived; but it

it seems to have been more considerable than at *Boston*. At *New-York*, three shocks were felt, about the hours of nine, eleven, and two the next morning. At *Philadelphia*, they had a shock about eleven o'clock, and another the next morning, about two. At the first of these, "most of the houses were "very sensibly shaken," but the other was not generally felt. Being but small in most places, and happening in the night, the *course* of this earthquake was not much attended to. The only remark I can find upon this, is in an account from *New-Haven*; in which it is said, "Its *course* was nearly from north "to south, and it continued about one minute."

OBSERVATIONS and REMARKS on the EARTHQUAKES of *NEW-ENGLAND.*

TO have a general view of the agreement and disagreement of the phenomena that have attended the earthquakes of *New-England*, it may be of use to make some general observations on the preceding HISTORICAL ACCOUNT.

It seems worthy of remark, that all the earthquakes of this country, have been of the same *kind*. Writers on this subject, have sometimes distinguished earthquakes into two different kinds, according to the different *motions* of which they have consisted.—In some, an *horizontal*, in others, a *perpendicular* motion has been chiefly observed. In the one, the earth seemed to move, as it were, from side to side: in the other, its motion seemed to be up and down. Both these motions have been united in the earthquakes of *New-England*. All, of which we have had any particular account, have come on with an

an *undulatory* motion, like that of a wave; which firſt riſes till it comes to its greateſt height, and then ſubſides; and in ſubſiding, ſpreads itſelf, with an horizontal motion, all around. This has appeared, with the moſt ſenſible evidence, to be the caſe, in all the earthquakes I have ever felt. They have all appeared, to me, to come on, as if a ſolid body, or a wave of earth, (if the expreſſion may be allowed) was rolling along under the ſurface of the earth; which firſt raiſed that part which was over it, and then left it gradually to ſubſide: the conſequence of which was, a ſtrong *undulatory motion* of the earth; which was immediately ſucceeded with an univerſal trembling, or very quick, jarring, vibratory motion, as though the earth was ſtruggling to recover its former poſition.

Another thing obſervable in the earthquakes of *New-England* is, they have all gone in much the ſame *courſe*. As to two or three of the earthquakes, we have no account of their *courſe*: but in all thoſe in which it was determined, there is a very great agreement. They are all deſcribed as coming from about north-weſt, and going off about ſouth-eaſt. As this was the caſe with all whoſe direction was obſerved, we may rationally conclude, that they all proceeded in pretty much the ſame general track; in a path from about north-weſt to ſouth-eaſt, though with many ſmall deviations and irregularities, in particular places. This, if I do not miſtake, has not been generally the caſe in the earthquakes of other places. The great earthquakes which have ſpread deſolation in *Sicily*, *Peru*, and *Jamaica*, inſtead of proceeding in any regular courſe, are deſcribed rather as inſtantaneous blaſts, which ſtruck dreadfully upwards,—not proceeding in any certain tract, from one country to another; but ſuch as burſt and rent a large circle of earth

all around. But with us, they have all proceeded in a different manner; and in a manner apparently regular;—fiercely driving along, as it were, in the ſame path, as though a paſſage had been opened for, or by them, from one country to another; in ſome places coming more near, and in others, running more remote from the ſurface of the earth. And the diſtance to which ſome, and probably ſeveral have run in the ſame courſe, has been greatly amazing;—nineteen hundred miles at leaſt, and how much more we know not.

From the laſt remark it ſeems probable, that the earthquakes of this country, have had their *origin* at ſome conſiderable diſtance to the north-weſt of *New-England*, and poſſibly at much the ſame place. Whatever might be the caſe with thoſe ſmall ſhocks that have had but a ſmall extent, or whereſoever they might begin, the larger ones have all been obſerved to come from the *north-weſt*; and they were of much the ſame violence at the moſt north-weſterly ſettlements, as at other places in the country. The place, therefore, where they have had their *origin*, muſt have been in ſome part of the unknown lands which lie to the north-weſt of *New-England*; and probably at ſome conſiderable diſtance from any of the *European* ſettlements; as there has been no account from any of them, in which it had not the ſame direction, coming on from the north-weſt. Whether the great ſhocks have all originated at the ſame place, we have no way to determine; but from the agreement of their courſes and motions, it ſeems not an improbable ſuppoſition.

There ſeems to have been a particular part of the continent of *North-America*, which has been the *ſeat* of the earthquakes of *New-England*, and to which they have always been confined.

To

To the south-west, they have several times reached as far as *Maryland*; but never so far as *Virginia* or *Carolina*. To the north-east, they have been bounded by *Nova-Scotia*; having never been felt much further than *Halifax*. From the unknown lands, at the north-west, they have gone off south-east, into the *Atlantic*: their extent this way, being greater than we are able to trace on either point of the compass. The province of *Massachusetts-Bay*, or rather, that part of *New-England* which is about the latitude of 43° north, where the river *Merrimack* empties itself into the *Atlantic*, has generally been the centre, or place of their greatest violence. If from this place, a line be drawn north-west, it will pretty well represent the central course of the earthquakes of this country: and from this line they have extended about four hundred miles to the south-west and north-east. It is not meant to be very particular, but only general, as to these boundaries.—And the whole country, within these limits, has been repeatedly shaken,—most violently about the middle, and least so towards the south-west and north-east boundaries. As far as can be gathered from the accounts, it seems probable, that most of the great shocks have reached to much the same places: the small ones, indeed, have not had such an extent; being felt only in different provinces and towns. But *all* the earthquakes, within the above-mentioned limits, have come from the same point, and ran in the same course: the great ones reaching to much the same extent, as though there was something to direct their motions the same way, and to confine them to the same limits.

With what *velocity* these earthquakes moved, it is not easy to determine. In many accounts of earthquakes, their motion has been said to be instantaneous, like that of the electrical

ſhock. The reverſe has been the caſe in the earthquakes of *New-England*. Inſtead of being inſtantaneous, their motion has never been very ſwift. To compute, indeed, with accuracy, with what velocity any of them moved, we have no ſufficient *data*. Had the times at which any of them begun, been carefully noted at places whoſe diſtances were known, it might have opened the way to ſome very curious concluſions. But all the accounts, excepting one of Profeſſor *Winthrop*, are too general to form any certain inferences of this kind. There is, however, one article in the accounts of the earthquakes of 1727, 1755, 1757 and 1761, from whence we may conclude, that the *velocity* of their motion, was conſiderably leſs than that of *ſound*. Moſt of the accounts of the earthquakes of 1727 and 1755, agree, that the roar was heard at leaſt half a minute before the ſhake began. The ſound, therefore, that was occaſioned by the approach of the earthquake, preceded the ſhock with a motion conſiderably ſwifter than that of the earthquake itſelf. Now, *ſound* moves about thirteen miles in a minute; and the motion of this was conſiderably ſwifter than the motion of the earthquake. In the earthquakes of 1757 and 1761, the ſound was alſo heard half a minute before the ſhock was felt: and as the report was much leſs, and therefore could not reach ſo far as in the larger ſhocks, the inference will be, that theſe ſmall ſhocks moved with a velocity conſiderably leſs than the larger one. And, indeed, the ſuppoſition ſeems not improbable, that the *velocity* with which an earthquake moves, ſhould bear ſome proportion to its *violence*,—to the ſtrength and force of thoſe cauſes, by whoſe operation it is produced. Whether there does not ſeem ſome evidence that this has been the caſe with us, the reader will judge for himſelf, from what

has

has been observed above. If this is the case, as I believe it is, future observations may determine it with much more certainty and precision, than any that have yet been made.

But although we are able to discern some appearances of agreement and similitude in those phenomena that have been mentioned, we cannot discern any in the *times* in which these earthquakes have happened. From their having all proceeded in the same course, one might be led to suspect, whether their causes, whatever they are, operating in the same direction, would not require nearly the same intervals of time, to gather sufficient force to produce the same effects. But nothing of this nature is apparent. The intervals of time, at which they have happened, have been very different, and without any apparent regularity. Not to mention the smaller shocks, there have been five which have been distinguished by their being much larger than the rest: those, I mean, of 1638, 1658, 1663, 1727 and 1755. Between the two former of these, there was an interval of twenty-eight years.—Between the two next, an interval of five years: then one of sixty-four; and between the two last, of twenty years. At a medium, this will make one in about twenty-seven years. But in these different intervals, there is no apparent order, regularity, or proportion, in the times of their happening. Neither does there seem to be any proportion between *the intervals of time*, and *the violence of the shock*. One would be apt to imagine, that the longer the causes were gathering strength, the greater would be the violence of the earthquake when it came: and yet that of 1755 was greater than that of 1727, though the interval of time had not been half so long. It is to be observed, however, that as our accounts of the earthquakes are but imperfect, as to their number,

number, and much more ſo as to the degree of their violence, all our reaſonings, upon this article, muſt be very uncertain.— Nor could we, without very accurate accounts of the time and violence of the earthquakes, the ſmaller ones as well as the greater, ſtate any proportion between the *times* and the *ſhocks*, ſuppoſing ſuch proportions to exiſt. But if there are any ſuch proportions, or any order and regularity, in their periods, it is not apparent; but rather the contrary, from all the accounts I have been able to collect.

It is alſo worthy of remark, that theſe earthquakes do not ſeem to have any *connection* with any thing that falls under our obſervation. It has been ſuſpected, by thoſe who account for the origin of earthquakes on the principles of electricity, and by many others, that there is ſome connection between the ſtate of the weather, or rather atmoſphere, and the happening of an earthquake. As our knowledge of this ſubject is ſo imperfect, it may not be amiſs to note every thing of this kind. And it is obſervable, that the earthquakes have generally happened in calm, ſerene and pleaſant weather. Some of the accounts are very imperfect in this reſpect: but, in general, they ſeem to agree pretty much in this particular. But though it has generally been the caſe, that the earthquakes have come on in fair and pleaſant weather, it has not been univerſally ſo.—In the earthquake which happened November 22, 1755, after the great ſhock on the 18th, the weather was not clear and fair, but dull, cloudy, and attended with ſmall ſhowers, and a briſk gale at ſouth-weſt.—And in March, 1771, there was a ſmall ſhock, when, inſtead of being fair weather, there was a heavy ſtorm of ſnow. But perhaps it is of no great conſequence to mention this. It has been more common for writers on this ſubject to attempt

attempt to find some *preceding signs*, or forerunners, of these events. And in this respect, fear and superstition have been abundantly fruitful. Philosophy has nothing to do with the many idle reports of this kind, that have prevailed among the vulgar. But among the many things that have been supposed to exist, there is one that deserves our notice, as having, probably, a real foundation in nature. Ancient and modern writers have supposed, that it might in some cases be a prelude to an earthquake, when the water, in deep pits, wells, caverns, springs, &c. is thrown into uncommon motions, disturbed, altered and changed, as to its course, kind, or quality. It is rational to suppose, that such events may, in some cases, proceed from those causes, which, in a little time, have burst out, and rent the adjacent country. Some curious observations of this kind, were mentioned by Messieurs *Dudley* and *Allin*, as happening a few days before the earthquake of 1727: and something of the same kind was observed previous to the earthquake of 1755. As these accounts have been mentioned,* it is unnecessary to repeat them here. I am far from supposing, that any certain prediction of earthquakes can be generally made from such observations; as such events may, and no doubt do happen, without being followed by any shocks; and earthquakes often take place without any such events. But at the same time, it can hardly be doubted but that the alterations observed in the water of these wells, was owing to the operation of the same causes, that in a few days burst forth with such violence as to shake all *New-England*. With regard to the *ill effects* that have succeeded earthquakes in some countries, it is well known there have been many and fearful accounts. In

* Vide p. 265 and 277.

In ſome places, they are ſaid to have been followed with great mortality, peſtilential diſorders, and the moſt raging ſickneſs. Nor is it improbable, that the air ſhould be infected with noxious effluvia, from the vapours that were before confined, and perhaps corrupted. It ſeems credible, that ſomething of this nature has been the caſe, and, probably, the *conſequence* of earthquakes, in ſome places. Many of theſe reports, indeed, ſeem to be much like what has been ſaid of the effects of comets, meteors, and the conjunctions of the planets.—But at the ſame time it ſeems probable, both from ancient and modern accounts, that in ſome places, peſtilential diſorders have, in fact, and probably as the conſequence, ſucceeded great earthquakes. Nothing of this nature has been the caſe in *New-England.* It is, however, highly probable, from the Rev. Mr. *Lowel's* obſervation,* that ſome very noxious vapour, or effluvia, attended the eruption of the earthquake of 1727: but no bad effects, no peſtilential diſtempers, no ſweeping ſickneſs, or uncommon diſorder or mortality, has been obſerved to ſucceed any of the earthquakes of this country; no otherwiſe, at leaſt, than what has been common at other times.

CONJECTURES on the CAUSES of theſe EARTHQUAKES.

IN this enquiry into the Cauſes of Earthquakes, it is not my deſign to enter into a particular diſcuſſion of the ſeveral hypotheſes philoſophers have aſſigned, as accounting for the production of ſuch phenomena.—I mean to conſider the ſubject

* Vide p. 268

ject no further than it has relation to the earthquakes of *New England*, and what may be gathered, as to their causes, from the preceding HISTORY and REMARKS.

From the phenomena and observations that have been mentioned, we may safely infer, that the earthquakes of *New-England* have been produced by *something which has moved along under the surface of the earth.* Whatever may have been the case in other places, all the earthquakes of this country, so far as we have any accounts of them, have been of the same kind; consisting, not of a simple instantaneous vibration, like that of an electrical shock, but of a gradual heaving, swell, or undulation of the earth. This has moved along in much the same path, with a motion not very swift: and it has reached deep enough below the surface of the earth, to affect and disturb the fountains, springs, wells and pits of water. These phenomena, are effects, which would naturally lead us to conclude, that the causes, whatever they may be, had their seat, rise and operations under the surface of the earth. And this conclusion from the *phenomena*, is strongly confirmed from *observation.*—For the shocks have come on, rose to their greatest height, and gone off, to all appearance and observation, as if they had been occasioned by the rolling of some solid body under the surface of the earth. In this manner Professor *Winthrop* describes that which happened November 22, 1755:—"I was then," says he, "sitting on a brick hearth: and the "sensation excited in me, was exactly the same as if some small "solid body, by moving along under the hearth, had raised "up the bricks successively, which immediately settled down "again."* The same observation has been frequently made

* Lecture on Earthquakes, p. 12.

by others; and is agreeable to all the accounts that can be collected. And from these accounts of the several phenomena of the earthquakes, and the observations that have been made upon them, I think we may lay it down as *a pretty certain fact*, that the earthquakes of *New-England* have been caused by something which has moved along under the surface of the country.

What thus moved under, and hove up the surface of the earth, was probably *a strong elastic vapour*. This is inferred from the phenomena that have attended the earthquakes.

Among these phenomena, there were some that preceded the earthquakes, and looked like a *previous preparation*. In the earthquakes of 1727 and 1755, in particular, it was evident, that the causes by which they were produced, were at work several days before they became ripe for an explosion. As tho' some grand fermentation was taking place in the bowels of the earth, the water, in several wells and springs, was uncommonly altered in its motion, colour, smell and quality. This was observed three or four days before there was any earthquake. Nothing could better agree with the origin and production of a subterraneous elastic vapour, than this circumstance. For however such a vapour be generated, by mixture, fermentation or fire, it would require some previous preparation, for its production, or before it would be collected in sufficient quantities to cause an explosion, or acquire sufficient force to move and shake the surface of the earth.

The *noise* or *roar*, occasioned by the earthquakes, has always been such as might have been expected from a subterraneous vapour, when fiercely driving along under the surface of the earth. What report might be expected from a strong elastic

vapour,

vapour, when its motion is confined and directed by a particular channel or paſſage, we may learn from that of a blazing chimney. The action of fire, when turning the inflammable materials, with which the chimney abounds, into flame and vapour, produceth a noiſe or roar of a very particular kind; and which ſeems to be different from almoſt any other: and there is nothing to which the report of our earthquakes is more ſimilar, or has been more often compared.

There is alſo an apparent agreement between the effects of a ſubterraneous vapour, and the *kind* and *motion* of the ſhocks. When the materials, from which a ſubterraneous vapour is produced, lie promiſcuouſly mingled and blended together, the effect of an exploſion would be a violent ebullition, or blaſt upwards; tearing and rending a circle of earth, all around. This ſeems to have been the caſe in the earthquakes of *Sicily*, *Lima* and *Jamaica*. When the vapours can have a regular diſcharge through any aperture in the ſurface of the earth, they will vent themſelves in copious effuſions and exhalations, and thus ſpend their force this way, as they gather ſtrength from time to time. Thus it has been with *Hecla* formerly; and with *Veſuvius*, *Ætna*, and other volcanoes now. But when the vapours are confined under the ſurface of the earth, and have ſubterraneous paſſages, or proper ſtrata, for them to run in, by the violence of their expanſion, they will heave up the ſurface of the earth, and thus cauſe, not an inſtantaneous concuſſion, but a progreſſive ſwell or undulation of the earth.— And this will be continued till the vapours, thus confined, find or force for themſelves a paſſage, where they may burſt from their caverns, and diſcharge themſelves into the open air.—

 And

And theſe are phenomena in all reſpects agreeing with thoſe that have attended the earthquakes of this country.

The ſtrength and force of ſuch a vapour, would be ſufficient to account for the *violence* of any ſhocks we have had. A very great force muſt be requiſite to heave up, and cauſe a progreſſive ſwell in the ſurface of the earth, and this, perhaps, from ſome depth below.—And with what force ſubterraneous vapours may be attended, we may form ſome idea from their effects. In thoſe which have ſhook *Veſuvius* and *Ætna*, it has been no uncommon thing to ſee them throw up at once, ſuch clouds of ſand, aſhes and pumice-ſtones, as are capable of darkening the whole air, and covering the neighbouring country with a ſhower of duſt, &c. to many miles diſtance. Great ſtones, alſo, of ſome tons weight, are often thrown to the diſtance of two or three miles, by ſuch exploſions. Monſ. *Bouguer* tells us, that " he met with ſtones in *South-America*, of eight or nine feet diameter, that had been thrown from the volcano *Catopaxi*, by one of theſe blaſts, to the diſtance of more than three leagues." In *Ulloa's* account, the whole plain, near *Latacunga*, is ſaid to be full of pieces of rocks, ſome of which were thrown, from the ſame volcano, to the diſtance of five leagues.† If ſubterraneous vapours, when they have had nothing to confine them, have acted with ſuch force, we may eaſily conceive that they muſt heave up, and cauſe a progreſſive ſwell in the ſurface of the earth, when their force was confined, and their motion directed by a particular paſſage.

The *eruptions* and *effuſions* that have attended our earthquakes, have alſo borne ſtrong marks of ſubterraneous vapour. That a vapour of ſufficient force to ſhake and move the ſurface of a whole

† Phil. Tranſ. for 1760, p. 592.

whole country, ſhould break out in many places, where it came near to the ſurface of the earth, is agreeable to the preſumption of theory. Thus it has been with ſeveral of our earthquakes. In that of 1727, there was an eruption at *Newbury*, attended with an effuſion of ſand, containing ſmall mixtures of ſulphur, and a very noxious, ill-ſcented vapour. Strong ſulphureous ſmells were obſerved in other places; and, as ſome ſuppoſed, there were alſo appearances of flame. In the earthquake of 1755, there were eruptions at *Scituate*, *Pembroke*, *Lancaſter*, &c. with large effuſions of ſand, probably of a ſulphureous nature. Whether this was the caſe with any of the other earthquakes, the accounts are not particular enough to determine. But in theſe, both the matter and ſmell attending the eruptions, afforded ſtrong marks and evidence of ſubterraneous vapours.

The earthquakes of *New-England* have alſo made ſuch *alterations* in the bowels, and upon the ſurface of the earth, as a ſtrong ſubterraneous vapour would produce. Very conſiderable alterations might be expected in the bowels, and upon the ſurface of the earth, and in the ſyſtem of ſprings, fountains, currents and ſtreams of water, from a vapour of ſuch force as to break thro' the ſurface of the earth, and of ſuch extent as to reach from one country to another. Such effects have always followed the larger ſhocks. In that of 1663, incredible alterations are ſaid to have been made in the ſurface of the earth at *Canada*, for many leagues through the country. Rocks and mountains were, in ſome places, thrown down, and conſiderably removed; and the channel in ſome parts of the river *St. Lawrence*, was very much changed and altered. In thoſe of 1727 and 1755, the ſurface of the earth, in ſome parts of *New-England*, was conſiderably

considerably broken and changed; and the whole system of fountains and springs, was greatly affected. Great alterations were made in wells, ponds, fountains and currents of water: some were dried up, others opened; new ones produced, and, in many, the kind, quality and quantity of the water was greatly changed.—Alterations in all respects similar to what might be expected from subterraneous vapours, fiercely driving along under the surface of the earth, with a force sufficient to move and shake so large a part of its surface.

This opinion agrees also *with the effects which the earthquakes have had on the water*. The earthquakes of *New-England* have been felt not only upon the land, but also upon the sea. Several vessels, which have been upon the coasts at the times of the larger shocks, have been very sensibly affected. To the people on board, the shocks seemed as if the vessel had struck upon a rock; or rather, as if something had thumped against their bottoms. This, it is probable, was the very case; and is agreeable to what might be expected from the operation of subterraneous vapours.

The earthquakes moved with a velocity sufficient to communicate the same kind of motion to the water that they did to the earth; and thus caused a very deep, large and extensive swell or wave. This wave, arising from the bottom, rolled along with much the same velocity as the earthquake moved: the effect of which, when it came to a vessel floating upon the water, would be a very considerable stroke or thump against the bottom,—more or less violent, according to the violence of the shock, and the depth of the water.—And in this manner have vessels, upon the coast, been affected;—some scarce perceiving it; others not at all; while to others it was pretty violent.

There

There have been other effects upon the water, such as a surprising flux and and reflux of the sea,—extraordinary agitations and commotions of the waters,—an uncommon destruction of fish, &c. These effects have not been common, and never but at a considerable distance from the coast of *New-England*. And they seem to be plain and evident marks and effects, of the discharge of the subterraneous vapours, at the bottom of the sea. Such a discharge, when small, would be sufficient to occasion the destruction of such fish as were near it: and when large, would put an end to the earthquake, and produce the most extraordinary agitations and commotions of the sea, by a furious eruption of vapours at its bottom; which would immediately force their way through, or carry up before them, the whole body of water that lay over them.

And thus as to the *conclusion*:—It might be naturally expected, that as the vapours, by which the earthquakes were caused, were some time in growing ripe, fermenting, or in a state of previous preparation, they would not be wholly spent or discharged at once, but leave small reminders at particular places. Thus it has proved in all the great earthquakes we have had. The vapours, by which they have been produced, have not been wholly spent at the first shock: but what has remained, and what has gathered after a great explosion, has produced various small shocks in several places, for some time after the great ones:—thus wasting and evaporating by little and little, as they were collected and prepared at first; till, by degrees, all has become quiet again.

Such have been the phenomena that have attended the earthquakes of *New-England*.—And to me, they appear to be such, as (viewed either together or apart) make it highly probable,

that

that what moved under, and hove up the surface of the earth, was *a strong elastic vapour*.*

The *origin* or *production* of such a vapour, may be accounted for from the CONTENTS of the earth. Much the largest part of the contents of the earth, will always remain hidden from our view, and beyond the reach of our knowledge. We have, however, penetrated far enough below its surface to find, that many of the bodies it contains, are of such a texture, or contain particles of such a nature, as to generate, or be easily turned into vapour. This is the case with coals, salts, sulphur, nitre, air, water, most kind of minerals, and all substances which contain oily particles. Such bodies, at least some of the particles they contain, are easily and often turned into a very strong, subtle, elastic vapour. With some, nothing more is necessary to generate a very powerful vapour, than a bare *mixture* of different bodies. Thus equal quantities of powdered sulphur and iron filings, being mixed with water, soon become too hot to be touched ; and in a little time emit flame and vapour. And if iron, oil of vitriol, and water, become mixed together, there will instantly arise a violent ebullition, with fumes copiously exhaling ; and which are so very inflammable, that if set on fire, they go off at once with a loud explosion. The same is also effected by *fermentation*. Instances of very strong elastic vapours, produced this way, are so common and obvious, that particular cases need not be mentioned. All separable, mixt and compound bodies, may be the subject of this operation : and the easier they are separable, whether by means of

* From the phenomena which have been mentioned, it seems probable, that this elastic vapour was a fluid, of the same nature as that which is now called *inflammable air*.

of water, air, or heat, the more readily they ferment.—And when they do ferment, they will produce a vapour more or lefs ftrong, according to the quantities of the fermenting matter, and the degree of the fermentation. But in no method is a more powerful vapour produced, than by *fire*. What an amazing effect will a fmall fpark of this have on nitre and fulphur, when made up into fuch a compofition as that of gun-powder! How fmall a quantity of this powder, when on fire, will generate a vapour of fufficient force to burft the firmeft rocks! Air, by the application of fire, becomes fo elaftic, as to break through all oppofition.—And there are many effects produced by the vapour of water, when intenfely heated, which make it probable, that the force of gun-powder is not near equal to it. And, in general, all combuftible bodies are capable of being turned into vapour, by the action of fire.—And fire feems to be a fluid, which is fpread through almoft all bodies whatfoever. It certainly exifts, in very large quantities, in the bowels of the earth.—Some parts, as the volcanoes are actually burning, and have been throwing out fire, flame, fmoke, cinder, rocks and lava, for many ages.—And where there are no fuch appearances of it, it exifts, and is diffufed in great quantities. That this is the cafe is evident from hot fprings,—the warmth that is always found in deep mines and pits,—and thofe burning mountains that have been thrown up from the bottom of the fea.—And when collected into large quantities, its effects on water, air, the fumes of fermenting minerals, and all kinds of combuftible bodies, would be to generate a vapour more or lefs ftrong, according to the quantities of the minerals of which it was compofed.

Thus, in the *contents* of the earth, we find ſufficient materials for the production of the moſt ſtrong, active and powerful vapour ;—and ſuch materials as do, in fact, produce moſt terrible volcanoes,—vapours that have hove up, and broke thro' the ſurface of the earth,—and earthquakes that have ſhaken the whole country, for twenty miles around *Veſuvius* and *Ætna*. —And ſuch exploſions and concuſſions are what all thoſe countries are ſubject to, which abound with ſulphur, nitre, and ſuch combuſtible materials.

As the *contents* of the earth will account for the *origin*, the *ſtructure* of it will account for the *motion* and *direction* of a ſubterraneous vapour. Were the globe a perfect ſolid, there could be no motion of a ſubterraneous vapour under its ſurface. But this is not the caſe.—Inſtead of being a perfect ſolid, the earth is of a *cavernous ſtructure* ; containing various pits, holes and caverns. Some of theſe are dry ; others are the fountains, or contain currents of water ; and others abound with the fumes of fermenting minerals, and with various kinds of vapour and effluvia. That the earth is thus of a cavernous ſtructure, is evident from the mines, ſprings, and currents of water, that are found below its ſurface, in every country, and in almoſt every place. And it is probable, that many of theſe ſubterraneous caverns may be of a great extent ;—ſome running in a direct, and others in long, crooked, unequal paſſages. —And by thus winding, meeting, croſſing and mixing with each other, they may form communications between very diſtant parts of the earth. The *manner* in which the ſolid and fluid parts of the earth are *diſpoſed*, is alſo worthy of remark.—In ſome places, they are found promiſcuouſly mingled and blended together, in a manner which has no apparent order

order or regularity. In other places, the various kinds of *ſolids* appear to be diſpoſed with the utmoſt apparent regularity, in the form of different and diſtinct *ſtrata* of clay, coals, ſalts, ſulphur, minerals, &c. It is thus alſo with the *fluids* ;—in many places, they are regularly collected into quantities, or fountains, within the bowels of the earth ; in others, they are conſtantly and regularly moving in perpetual ſtreams and currents : ſome of which are charged with ſulphureous particles ; others with thoſe of iron ; and others, with various other tinctures and mixtures.

And from this *Structure* of the earth, *the motion* of a ſubterraneous vapour would receive *its direction.* For vapours, generated and increaſing in the bowels of the earth, if they found no vent upwards, muſt naturally take their courſe and ruſh fiercely along under the ſurface of the earth, according as they found ſubterraneous *paſſages* or *ſtrata,* of proper materials to conduct them.—And it ſeems as if ſomething of this nature muſt be the caſe in this part of *America.* That there ſhould be a particular part of the country, as to width, to which the earthquakes of *New-England* have repeatedly reached ; that they ſhould all be of the ſame kind,—come from the ſame point,—and proceed in the ſame path ;—theſe phenomena cannot be ſuppoſed to be the effect of what is called chance or accident. It is evident there muſt have been ſomething which ſerved as *conductors.* If *ſubterraneous paſſages,* of ſuch extent as theſe earthquakes, ſhould be admitted, it would be difficult to account for the width of the earthquakes, on that hypotheſis. The more probable ſuppoſition ſeems to be, that there are ſome particular *ſtrata,* which have ſerved as fuel or conductors to the vapour. And that this was the caſe, ſeems further probable from the

 ſulphureous

sulphureous mixtures that have been thrown out at the different eruptions. Instances of these eruptions are mentioned in the accounts of the earthquakes of 1727 and 1755.—And they are such as make it probable, that there is some particular *stratum* under the surface of the country, which has served and will serve to direct the motion of the subterraneous vapour, from the places of its origin, to that of its grand final eruption.*

On this account of the Causes of the Earthquakes of *New-England*, it may not be amiss to remark, that part of it seems to be matter of *fact*, and part matter of *conjecture*. As the causes lie out of sight, and beyond the reach of observation, we have no way to come to the knowledge of them, but by general reasonings from the phenomena that fall under our observation. These phenomena, I may venture to say, have been fairly related :—but whether the inferences that have been drawn from them, are just,—the conjectures, such as are probable,—the conclusions, well supported,—and the evidence, such as might

* Such *strata* are not at all uncommon. Many countries are known to abound with, and to be distinguished by them. "We have an instance of it in the chalky and flinty countries of *England* and *France*, which (excepting the interruption of the channel, and the clays, sands, &c. of a few counties) compose a tract of about three hundred miles each way." Phil. Transf. for 1760, p. 587. The volcanoes in the *Andes*, are in all probability derived from the same *stratum* of combustible minerals ; the extent of which cannot be less than five thousand miles,—for so far do the mountains and volcanoes extend.—And thus in *North-America*, if we may give credit to *L. Evans*, in descending from the mountains which adjoin to the western lakes, the same sets of *strata*, and in the same order, are generally kept up.

In some countries, earthquakes have ceased upon the breaking out of volcanoes. If there were volcanoes in this part of *America*, which might serve to interrupt the *stratum*, and as a vent for the subterraneous vapours to discharge themselves, it is probable the earthquakes of *New-England* would not run in such a regular manner, through such an extent of the country.

might have been expected,—these are submitted to the judgment of others. Hypotheses may be of use to put us upon further enquiry, and a more critical examination; but are never to be received, any further than they are supported by proper evidence.

GENERAL REFLECTIONS on EARTHQUAKES.

THE preceding ACCOUNTS, OBSERVATIONS and CONJECTURES, have been confined to the earthquakes of *New-England.*—But they will naturally lead us to some GENERAL REFLECTIONS on the nature, use and effects of these formidable phenomena. Thus,

If we are right in our conjectures on the causes of earthquakes, we may conclude, that the globe always has been, and will be subject to such concussions. From the earliest ages, of which we have any accounts, this has been the case. Many parts of the earth bear the marks of great and furious eruptions; not a few of which, were prior to all historical monuments and records. The eruptions of the noted *Ætna,* may be traced back an hundred years before the siege of *Troy.** *Vesuvius* was a volcano before the foundations of *Herculaneum* and *Pompeii* were first laid. These cities were covered by an eruption of *Vesuvius*, A. D. 79. Their foundations and pavements are all of that melted and vitrified substance called *lava,* which *Vesuvius* had thrown out;—which is a proof of great eruptions, prior to the foundations of these cities.† How long these volcanoes, or those in *Iceland,* the *East-Indian* islands, and

* According to M. *D'Orville.*

† Phil. Trans. for 1771. Art. 1.

and *South-America*, have been burning, we have no hiſtory or tradition ancient enough to inform us. Many of their effects bear the marks of more furious eruptions than any there have been in modern times. The ſoil for more than twenty miles, round *Naples*, by its cinder, ſtones, burnt matter and lava, appears to have been the production of very ancient ſubterraneous fires, earthquakes and eruptions.* The *Appenines*, a chain of mountains which divide the continent of *Italy* from north to ſouth, and extend even to *Sicily*, diſcover many tokens of an internal fire; and were judged, by that celebrated philoſopher, M. de la *Condemine*, to be a chain of ancient volcanoes. This is alſo the caſe with that long chain of mountains in *South-America*, known by the name of the *Andes*. Theſe mountains run from 45° ſouth latitude, to ſeveral degrees north of the line, and alſo throughout all *Mexico*; being, according to Monſ. *Bouguer's* account, five thouſand miles in extent. The ſeries of volcanoes, formed by theſe mountains, is interrupted: many are totally extinguiſhed; and there are many which are ſtill burning; and many of the ancient ones frequently burſt out again.‡ Several of the *Weſt-Indian* iſlands, the *Azores*, *Teneriffe*, and moſt high mountains, either contain volcanoes, or, by the veſtiges of calcination and vitrification, ſhow the former effects of them.—And as ſeveral iſlands and mountains have been ſunk, ſo we have authentic accounts of ſeveral that have been thrown up from the bottom of the ſea, by ſubterraneous fires. Such effects with the relations of hiſtory, afford plentiful evidence, that the globe has always been ſubject to and greatly affected by ſubterraneous fires, earthquakes and volcanoes.

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* Phil. Tranſ. for 1771. Art. 1.

‡ *Condamine's* Travels into *Italy*.

The ſame cauſes which have produced ſuch effects on the ſurface, are undoubtedly ſtill exiſtent in the bowels of the earth. Proper periods of time may be requiſite for them to grow ripe, or gather ſtrength ſufficient to cauſe an exploſion or earthquake. But as the materials from which ſubterraneous vapours are formed, conſtantly exiſt in the bowels of the earth, they will be as conſtantly fermenting; and thus increaſing the quantity and force of the vapours, till they ſhall become ſufficient to break through all oppoſition, and force for themſelves a paſſage thro' the earth. And although they may in ſuch ways be diſcharged from time to time; yet, ſo long as the ſame powers ſhall ſubſiſt in matter, new vapours will be produced; and, of conſequence, the ſame effects, after proper intervals of time, will again take place. Nor are they to be viewed as marks of any diſorder or irregularity in the works of nature. For,

Notwithſtanding all their terrible effects, earthquakes ſeem to be a neceſſary conſequence of ſuch laws of nature, and powers in matter, as are, upon the whole, greatly beneficial to the globe. There is no phenomena in the whole courſe of nature, ſo formidable as that of an earthquake.—Nor is there any that has ſpread more univerſal horror, calamity and deſolation. Hiſtory, ancient and modern, abounds with accounts of large countries that have been ſhaken,—whole cities that have been ſunk and covered,—and immenſe numbers of mankind that have been deſtroyed, by theſe dreadful convulſions of nature. In the earthquake which ſhook *Sicily*, in the year 1693, fifty-four cities and towns, with an incredible number of villages, were either deſtroyed or greatly damaged, and about ſixty thouſand perſons periſhed. In that at *Jamaica*, in 1692, almoſt the whole of *Port-Royal* was ſwallowed up, and large numbers of

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its inhabitants buried in its ruins.—And in the earthquake at *Lima* in *Peru*, in 1746, all the buildings in that city, and in the port of *Callao*, except about thirty, were ſunk, or laid in ruins, and great numbers of people deſtroyed :—four hundred and fifty-one ſhocks, many of which were equal to the firſt, ſucceeding in the ſpace of four months. The deſtruction of *Liſbon*, by the earthquakes in 1755, was alſo attended with the moſt tragical ſcenes of deſolation, death and miſery. And yet, notwithſtanding all theſe dire effects of earthquakes, it is very poſſible, that the laws and cauſes from whence they ariſe, may be a neceſſary proviſion, and a real advantage to the globe. The power of gravity, the wind and water, rain, heat and cold, have occaſioned the deſtruction of vaſt numbers of mankind : and yet they are a general advantage to the earth, and to its inhabitants ;—and ſuch an advantage, that no creature could live on this globe without them. And ſince they produce an *overbalance* of good, they are to be eſteemed advantageous and beneficial upon the whole ; although in ſome particular caſes, they may be attended with very dangerous and fatal effects. This, it is probable, is the caſe with all the laws, powers and operations of nature ; and to all thoſe agitations and concuſſions to which the earth is ſubject.

To enumerate all the ends to which theſe formidable phenomena may ſerve in the natural world, would require higher degrees of knowledge than it is probable we ſhall ever have of this ſubject. And yet, perhaps, we may ſee enough to convince us of the wiſdom and benevolence of the Creator, in making the globe ſubject to ſuch concuſſions. Theſe extenſive and powerful agitations tend to weaken the attraction, looſen the parts, and open the pores of the earth ; and thus to fit and

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prepare it for the purposes of vegetation, and for the various kinds of produce that are necessary for the support of animal life. Were an insuperable bond of attraction to take place on the surface, or in the bowels of the earth, without something to oppose its power,—fluidity, motion, vegetation, and all nature would be at a stand. The power of gravity tends to this: And hence we find it necessary, by the operations of agriculture, to break the surface of the earth, to loosen its parts, and open its pores, and thus weaken its attraction, that it may be fit for the production of such fruit and grain as we want in the course of the year. An earthquake performs that in the bowels of the earth, which the various methods of agriculture perform on its surface.—And it is probable, that the former is equally necessary to the purposes of vegetation, as the latter.—And what seems to confirm these conjectures, it is observable, that those places which are most subject to earthquakes, are the most noted, *cæteris paribus*, for the fruitfulness of its soil, and the plenty of its produce. Thus *Italy*, *Peru*, *Manilla*, and especially *Ætna* and *Vesuvius*, places greatly subject to earthquakes, are celebrated for an uncommon fertility. There are other important ends which may be answered by earthquakes. Those subterraneous vapours, by which they are caused, seem necessary to prevent the inward parts of the earth from becoming too dense, compact and hard, in consequence of their attraction.—And when these vapours are collected in large quantities, it may be necessary to have them discharged into the atmosphere, to prevent a dissolution of the globe through the force of their elasticity or repulsion. It may also be necessary to have new subterraneous passages opened,—old ones diverted from their former courses,—and new communications establish-

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ed between different countries,—that all parts of the earth may be ſupplied with ſuch kinds and quantities of water and air, as the growth of bodies, in the bowels and upon the ſurface of the earth, may require ; and that the ſolid and fluid parts of the earth may be kept in their due place, connection and order.—And, in general, we may preſume, from the analogy of nature, that there may be, and no doubt are, many ends and uſes to which ſubterraneous fires and earthquakes may ſerve, of which we have as yet no ideas or conjectures. But however theſe things may be,

It is probable, that our knowledge of this ſubject will increaſe, as all other branches of natural knowledge have done, and by the ſame means, obſervation and reaſoning. In the contents and ſtructure of the globe, the Creator of it ſeems to have made proviſion for the production of ſubterraneous vapours and exploſions. Earthquakes may of conſequence be expected, at proper intervals of time, in every country and climate, ſo long as the earth ſhall continue to exiſt in its preſent form. As theſe events happen, poſterity will have opportunity to examine their phenemena, to note their effects and operations, and to mark all their differences and agreements : and, of conſequence, they will be obtaining more and more inſight into their nature, cauſes and effects. The methods of reaſoning which are now happily introduced into philoſophical ſubjects, though their effects may be ſlow, are yet certain and progreſſive. Every age will be doing ſomething for the next.—And the ſeveral philoſophical ſocieties already eſtabliſhed, by collecting and recording obſervations, are, and will be, providing materials for the ages that are to come.—And when a ſufficient number of obſervations ſhall be thus collect-

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ed, inferences may be drawn, and conclusions may be formed from them, of which, as yet, we have not the least thought or suspicion. It has been thus in all other branches of philosophy: and the same accuracy of observation and reasoning, when applied to the philosophy of earthquakes, will probably bring to light things, of which we have now no knowledge or conception.

From any knowledge we yet have of the nature and causes of earthquakes, nothing would appear more romantic, than to attempt to predict when such formidable concussions will happen. We know so little of their causes, much less when these causes will have collected sufficient force to burst forth and shake the adjacent country, that we have no way to form any rational conclusions as to the time when an earthquake will happen, from any inferences founded on the knowledge of the nature and operations of their causes. Nor can we receive much, if any, help from any *preceding signs*:—I do not mean those which fear and superstition have formed; but from any regularity of their periods,—state of the atmosphere,—uncommon motion of wells, springs, and the like.—For if there is any connection between things of such a nature, and the happening of an earthquake, it is what we do not understand.

But our ignorance of these things ought not to be made an argument, that there is not in reality any regularity or order in these events; or that it will always be impossible to discover so much of the nature and operations of natural causes, as to discern the same simplicity, order and harmony, in the several phenomena of earthquakes, as are apparent in many other works and operations of nature. In all those works of nature, of which we have any tolerable conceptions, stated laws, and a

ſteady regard to them, have been obſerved.—And this has been manifeſt and apparent in the ſame degree as our knowledge of any ſubject has been advanced. There was a time when univerſal confuſion and diſorder were ſuppoſed to prevail in the courſes, motions and appearances of the heavenly bodies. But as the knowledge of the true aſtronomy increaſed, the moſt perfect order, harmony and proportion has been diſcovered in the motion and appearance of every ſtar, planet and comet.—And it is now well known, that all the ſuppoſed irregularity in any of theſe bodies, was nothing more than want of knowledge, and confuſion of ideas in the obſerver. If we may reaſon from analogy, the concluſion will be, that it is the ſame in all other caſes. It can hardly be doubted, therefore, but that there is the ſame harmony, rule and order,—the ſame general and ſtated laws, in the cauſes and operations of earthquakes, as there are in all other events of nature. No reaſon can be aſſigned why theſe alone, of all the works of GOD, ſhould be made up of irregularity and confuſion. It muſt, therefore, be ſuppoſed, that earthquakes (like all other events that depend on natural cauſes) are ſubject to certain and determinate laws and rules, which are in themſelves conſtant, regular and harmonious,—whether theſe laws, or this regularity, is known to us or not.

The ancient *Egyptians* and *Chaldeans*, by a long courſe of obſervations, are ſaid to have been able to foretell the appearance of comets, and the approach of earthquakes.* The greateſt philoſophers have ſuppoſed their predictions of this kind were founded not on any knowledge they had of the laws and powers of nature, but on the vain arts of judicial aſtrology. This might be the caſe.—It is, however, to be wiſhed, that we could

* *Diod. Siculus.*

could be a little more certain what knowledge the *Egyptians* pretended to in this matter. It is well known, that the ſciences were much cultivated among that diſcreet people. Geometry and aſtronomy, if they were not begun, received very great improvements from them. The *Greeks* had all their aſtronomical learning from *Egypt*. *Pythagoras* got the knowledge of the true ſyſtem of the univerſe from the *Egyptian* prieſts.—And their advances in ſeveral parts of the mathematics, were great and uncommon. How far they were acquainted with the aſtronomy of comets, I am not able to ſay. Some of the *Chaldeans*, and *Pythogorian philoſophers*, taught many things as to the nature, orbits and revolutions of comets; which, though long diſregarded, modern aſtronomy has adapted, and abundantly confirmed.* And that there was nothing impoſſible,—nothing romantic, in attempting to predict their appearance, the great *Halley* has fully demonſtrated. And whether they might not have ſome knowledge as to the philoſophy of earthquakes, which, thro' the ignorance and barbarouſneſs of after ages, might be loſt to the world, ſeems worthy of enquiry.

But however this may have been, it is at leaſt poſſible, that regularity, order and laws may be diſcovered in theſe, as well as in other works of nature. It is, indeed, but very little that is yet known of the nature, cauſes and operations of theſe events. It will, probably, require the obſervations of many ages to digeſt and form them into a proper ſyſtem.—And a long courſe of obſervations may open new ſcenes to poſterity, and enable them to form concluſions,—I had almoſt ſaid *predictions*,—which to us would appear wild, abſurd and ridiculous. To me there appears as much ground for ſuch a conjecture, as *Se-*

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* *Gregory's* Aſtronomy. Book v. ſect. 1.

neca had ſeventeen hundred years ago for his, relative to comets; but which has literally been fulfilled.* But leaving theſe things to the ages that are to come,—

From contemplating theſe mighty works of nature, a philoſophic mind will naturally riſe in admiration and reverence, to the FRST GREAT CAUSE OF ALL! In all the works of nature, we find plain marks of that wiſdom, power and goodneſs, with which the whole plan, frame and conſtitution of it, was firſt formed and adjuſted. As all natural effects take place in conſequence of cauſes and laws derived at firſt from GOD, true philoſophy agrees with the holy ſcriptures, in aſcribing all ſuch events to his agency. It was no doubt with a view *ultimately* to *moral* purpoſes, that the laws of nature were firſt eſtabliſhed: and nothing can be better adapted than many of their operations, to awaken and direct the attention of mankind to the ſupreme Governor of the world. By the operation of natural cauſes, the Deity often 'ariſeth to ſhake terribly the 'earth.' 'He looketh on the earth, and it trembleth: he 'toucheth the hills, and they ſmoke.' 'He removeth the 'mountains, and overturneth them in his anger.' 'The pil-'lars of heaven tremble, and are aſtoniſhed at his reproof.'

Amidſt ſuch convulſions of nature, ſtrong impreſſions of the power and majeſty of GOD, will naturally take poſſeſſion of the human mind. Mankind will ſee and feel their dependence upon their Creator,—with the wiſdom, benefit and advantage of

* 'A time,' ſaid this excellent philoſopher, 'will come, when thoſe things 'which now lie hid, will at laſt be brought to light, by length of time and the 'diligence of poſterity: for it is not one age that is ſufficient to make ſuch great 'diſcoveries.' *Seneca*, Nat. Queſt. lib. vii. chap. 25. May we not venture to ſay the ſame of earthquakes?

of ſuch a ſteady courſe of virtue, as leads to an habitual truſt in his providence and protection. Such unuſual and great events will powerfully awaken their attention to *morals*, and thus promote the advantage, although it may occaſion loſs and terror to mankind.

To pretend to be above fear, or to attempt to be unmoved with ſuch concuſſions of nature, would argue, on the one hand, a folly or a pride unworthy a philoſophic mind : and on the other, to give way at every ſuch event, to ſuch confuſion of thoughts and paſſions, as leaves no command over the mind, is a weakneſs as much as poſſible to be avoided. Of this we may at all times be certain,—the preſent frame of nature will ſubſiſt ſo long as Infinite Wiſdom and Goodneſs ſee it to be fit.—And no event will ever take place in the natural world, which was not foreſeen by him who is the AUTHOR OF NATURE, and deſigned to anſwer ſome wiſe and benevolent purpoſe. Of his favour mortals may be ſure, ſo long as they maintain a ſteady regard to the rules of virtue. This will always be productive of ſafety and happineſs ; though the immediate effect of the preſent convulſions of nature, will probably be as the poet ſays,

> *Terra tremit : fugêre feræ, et mortalia corda*
> *Per gentes humilis ſtravit pavor.*

IX. *An Account of* West-River Mountain, *and the Appearance of there having been a Volcano in it. In a Letter from* DANIEL JONES, *Esq;* *of* Hindsdale, *to the Rev.* JOSEPH WILLARD. *President of the University at* Cambridge, *V. Pres. A. A.*

Hindsdale, *November* 2, 1783.

SIR,

I RECEIVED your's of the 18th of August last, and observed the contents: and as I am not only willing, but desirous of doing all in my power to aid the literati in their pursuit of knowledge, immediately upon the receipt of your letter, (altho' I have often been upon *West-River Mountain)* repaired there again, with the best guides, and thoroughly explored the same.

The Mountain is situate about twelve miles north of *Massachusetts* line, on the east side of, and adjoining *Connecticut-River*, in the county of *Cheshire*, and state of *New-Hampshire*, and opposite the mouth of *West-River*, from which its name arises.

The Mountain, in all its parts, contains about three thousand acres of land, and is very uneven. The south and west ascents, very steep: the north and east not so steep, but very ragged.

On the south side of the Mountain, about eighty rods from the summit, there has been an eruption,—perhaps not within the present, or last century. The peasants, in the neighbourhood of the Mountain, discovered this place, and became possessed with the idea of gold dust being in the Mountain, and that it melted down into a solid body, by the extreme heat of

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the Mountain, at the time the eruption happened: in conſequence of which, they went to work in ſearch of the ſuppoſed treaſure; and after fruitleſs ſearches, formed larger connections, entered into covenant with the proprietors of the land, and with one another, to make ſearch for all kinds of mine and mineral. They have dug down about ſeventy or eighty feet; and in ſome places, where the rocks permit, twenty feet wide; but they are now impeded by the rocks, and the water that comes from the Mountain above the hole. The external parts of the hole is entirely rock, and in many places much burnt and ſoftened. There are ſmall holes in various places of the rock where they dig, like the arch of an oven, and the rock ſeems to be diſſolved by heat; the cinders and melted droſs adhere to it, and hang down in drops like ſmall icicles, ſomething reſembling in colour, the cinders of a furnace, or black glaſs, and it is ſo faſtened to the rock, that it appears as if it was originally part of the ſame.

They dig out of the hole, near the ſurface, various ſtrata of earth, or mineral; and in digging a drain to let out the water, they find a great plenty of the ſame kind of earth; and as it lies in the ground, the different complections are very curious to obſerve: there is a very fine ſoft yellow-oker, which, burnt, makes a good Spaniſh brown; there is another ſtrata, reſembling levigated antimony, the particles very ſoft; another of a faint yellow, fine, ſoft, and very greaſy, which quality is not loſt by lying on the ſurface of the earth, for a long time, expoſed to the ſun and air; there is another that reſembles a peach bloſſom in colour, but the texture more like the oker: and theſe various mineral, or earth, are not intermixed. At the mouth of the hole, there was blown out melted droſs, which ſtuck to

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the rocks; and in the hole was found various pieces of ſtone, which appeared to be diſſolved by fire, and the ſides of the rock blackened by fire; ſo that this hole muſt have been filled up ſince the eruption took place.

The miners inform me, that in the morning they frequently obſerve upon the earth that has been thrown out, ſomething very white, and by touching it with their tongue ſuppoſe it to be ſalt-petre.

In my late ſearch, I went to the top of the Mountain, directly above the place where the before-mentioned eruption happened, to ſee if there was a crater. The peak is ſmall, and there are about twenty rods of ground on the ſummit, which is rather hollow, where water ſtands in a wet ſeaſon (as is common in mountainous countries) but no regular crater. The hollow is oblong, and would have been, propably, had there been a great volcano (unleſs the heat had been ſo intenſe as to have diſſolved a prodigious ridge of ſolid rock, about fifty feet to the weſt of this hole) ſo to the top of the Mountain, which forms one ſide of a large dingle, from the top to the bottom of the Mountain, four or five hundred feet perpendicular; where immenſe quantities of rock have fallen down, occaſioned, probably, by exploſions in the Mountains, or earthquakes. That there have been various exploſions in the Mountain, is beyond a doubt, and in various places, which have occaſioned great quantities of ſtone and rock to fall from the Mountain; but I am inclined to think theſe exploſions are not frequent, as formerly, even fifty years ago; for I am told by ancient people of veracity, who formerly dwelt at *Fort-Dummer* (oppoſite the Mountain) that there were frequently exploſions, and fire and ſmoke were emitted.

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The laſt exploſion that I recollect, happened about five or ſix years ago, the noiſe reſembling that of an earthquake, and the earth trembled conſiderably where I was, about four or five miles from the Mountain; my herd of cattle were greatly terrified thereby, and run together through fear.

That there has been ſomething more than a ſudden exploſion, every one that views it muſt be convinced: but that there has been any conſiderable volcano, ſo as to cauſe the earth above to fall in or ſettle, no one, I preſume, will pretend.

I am, Sir, with great reſpect,
your very humble ſervant,
DANIEL JONES.

The Rev. JOSEPH WILLARD.

X. *An Account of Eruptions, and the present Appearances, in* West-River Mountain. *In a Letter from Mr.* CALEB ALEXANDER, *of* Northfield, *to Mr.* CALEB GANNETT, *Rec. Sec. A. A.*

Northfield, *May* 18, 1779.

SIR,

ACCORDING to your desire, I have visited the volcano upon the height of *West-River Mountain*, and shall do myself the pleasure to inform you concerning the various reports and particulars, relating to this place.

How long since it was first discovered, I am not able to ascertain. An old gentleman informs me, that fifty years since, he heard noises on that Mountain, as loud as the explosion of a great gun. Some years after, similar noises were heard, at the distance of fourteen or fifteen miles. Several times very violent eruptions of fire have been seen, the flame ascending very high into the air. Once in the winter there was an eruption. The years when the preceding eruptions happened, I cannot inform: the last was twenty-seven years since, which was the most violent eruption ever known in that place: it was towards the close of a dark evening, when it was first perceived, being preceded by a louder noise than common; then directly was seen the fire, which was seen to burn for several hours.

What I have written is by information: yesterday I was at the place myself. It is nearly upon the top of a very steep craggy mountain: by observation, I apprehend there were two places where the fire issued out; one of which is between two solid rocks, nearly a foot in diameter, but almost filled with the calcined matter caused by the fire, part of which appears similar

lar to burnt sand, intermixed with cinders. The surface of the rocks, for a considerable distance, indicates that there have been very intense fires, and probably melted matter upon them, for they are turned into perfect cinders.

The other place where the eruption has been is so destroyed, that I can inform but little with regard to it: only upon one side the rock is greatly calcined.

A number of gentlemen, apprehensive that there is some valuable mine in this Mountain, have undertaken to penetrate the bowels thereof. Accordingly, they have dug nearly eighty feet, in a perpendicular direction, into the Mountain, following a vein of matter, appearing similar to oker, both yellow, red, and brown; also, very often, they find pieces of cinders, like those which I have sent you. This vein, in some places, is sixteen feet in diameter, in other places not more than five.

In digging, they often find strata of this calcined matter, with a considerable mixture of other substance, appearing as if it had been intensely burned. I descended to the bottom of this (truly hideous) pit, and observed, that the rocks, in many places, were turned into cinders.

I am not able to determine, whether there be any thing of a sulphureous nature on this Mountain; but this I dare affirm, that there have been several eruptions: but whether it may, with propriety, be called a volcano, I know not. This determination is submitted to the judgment of gentlemen more acquainted with the nature of volcanos, than I can pretend to be.

I send you, for observation, two pieces, that were taken one from the top and the other seventy feet under ground.

I am, &c.

CALEB ALEXANDER.

XI. *Observations made at* Beverly, *Lat.* 42° 36′ *N. Long.* 70° 45′ *W. to determine the Variation of the magnetical Needle. By the Rev.* JOSEPH WILLARD, *President of the University at* Cambridge, *V. Pres. A. A.*

AN attention to the variation of the magnetical needle, it is well known, is of great importance at sea, nor is it of small consequence upon the land; especially in *North-America.* From the first settlement of this country, the lines between towns, and between lots of land appropriated to individuals, have been determined by the magnetical needle. If the variation always continued the same, no difficulty would ensue, in again tracing the lines, upon the same magnetical course; but as it alters from time to time, the lines run in any succeeding years must deviate from the first, and from one another, unless proper allowances are made for the alteration.

From the want of a sufficient number of observations, and of attention to this subject, in those who have surveyed the lands in this country, difficulties have arisen at one time and another, between towns and individuals. To remedy this inconvenience for the future, this Academy, some time ago, recommended magnetical observations, to determine the variation, which it is to be hoped will be made in various parts of the country, and at proper intervals of time, and be uniformly attended to by our surveyors. Since this recommendation, I have endeavoured to determine the variation at *Beverly,* with as much exactness as I was able. With this view, I procured an azimuth compass, of Dr. *Gowin Knight*'s invention. It appears to be good

good of its kind, and is furniſhed with a vernier, pointing out the azimuth to 5′; but the eye may pretty eaſily determine by it to 2′, and ſometimes to 1′. To obſerve by this compaſs, I aſcertained the going of my clock to great exactneſs, and on five different days, took ſeveral magnetical azimuths, both before and after the ſun paſſed the meridian, and noted the moments, which I have put down in apparent time. For theſe times, I have calculated the true azimuths by ſpheric trigonometry, and have carried out the variation for each obſervation ſeparately. On two days, I alſo determined the variation, by taking magnetic azimuths, at correſponding altitudes of the ſun, making proper allowances for the change of declination, between the obſervations of the forenoon and afternoon. On each of the days, ſome of the obſervations differ ſeveral minutes from others; but this I cannot attribute to want of attention, as I am conſcious that I made them with all the care in my power. The differences, I ſuſpect, principally aroſe from the difficulty of determining, with entire exactneſs, when the ſhadow from the hair was on the line beneath; and when in two obſervations, the error ſhould be on different ſides, the ſum might make a number of minutes. But I have the ſatisfaction of finding the mean reſults for the ſeveral days well agreeing with each other, which is a good evidence that the reſult of the whole muſt be, at leaſt, very near the truth.

Theſe obſervations and deductions are now humbly ſubmitted to the Academy, with wiſhes that they may ſubſerve the deſigned purpoſe.

JULY

Ap. times of obs.	Sun's mag. az. per obs.	Sun's true az. per cal.	Varia. of the need.
	JULY 27, 1781.		
11h 34′	S 8° 2′ E	S 15° 9′ E	7° 7 W.
11 36	7 0	14 2	7 2
11 50	S 1 10 W	5 57	7 7
11 58	5 55	1 15	7 10
12 4	9 28	S 2 26 W	7 2
12 20	18 45	11 45	7 0
12 26	22 15	15 10	7 5
12 28	23 30	16 17	7 13
Variation of the needle by a mean of 8 observations, July 27,			7 5¾
	JULY 28.		
11h 44	S 2° 25′ E	S 9° 19′ E	6° 54′ W.
12 4	S 9 15 W	S 2 20 W	6 55
12 6	10 35	3 30	7 5
12 8	11 45	4 40	7 5
12 22	19 45	12 46	6 59
12 26	22 5	15 2	7 3
12 30	24 15	17 16	6 59
Variation by the mean of 7 observations, of July 28.			7 0
	JULY 30.		
11 52	S 2 30 W	S 4 37 E	7 7 W.
12 2	8 15	S 1 10 W	7 5
12 6	10 28	3 28	7 0
12 18	17 28	10 19	7 9
12 26	21 55	14 47	7 8
Variation by the mean of 5 observations, of July 30,			7 5⅘
	JULY 31.		
11 29 32″	S 10 10 E	S 17 7 E	6 57 W.
11 39 32	4 35	11 37	7 2
11 43 32	2 20	9 23	7 3
11 51 32	S 2 5 W	4 51	6 56
11 55 32	4 32	2 34	7 6
11 59 32	6 40	0 16	6 56
12 1 32	7 50	0 53 W	6 57
Variation by the mean of 7 observations, of July 31,			6 59 4/7
	AUGUST 1.		
11 53 52	S 3 32 W	S 3 28 E	7 0 W.
11 59 52	7 2	0 4	7 6
12 1 52	8 0	1 4 W	6 56
12 3 52	9 10	2 12	6 58
12 15 52	15 58	8 59	6 59
Variation by the mean of 5 observations, of August 1,			6 59⅘

Variation

Variations determined by magnetic azimuths, taken at equal altitudes of the sun, forenoon and afternoon.

August 6.

A. M.		P. M.		Difference.		½ Diff. = Variation.	
68°	28′	82°	30′	14°	2′	7°	1′ W.
65	30	79	20	13	50	6	55
63	50	77	35	13	45	6	52½
63	30	77	15	13	45	6	52½
63	0	77	0	14	0	7	0
62	30	76	32	14	2	7	1

Mean variation by the above six observations of August 6,	6	57
Equation for change of declination,		+ 4
Variation,	7	1

August 15.

67	30	81	30	14	0	7	0
67	10	81	5	13	55	6	57½
66	42	80	40	13	58	6	59
66	15	80	18	14	3	7	1½
66	2	79	55	13	53	6	56½
64	45	78	40	13	55	6	57½
64	12	78	8	13	56	6	58
63	58	77	48	13	50	6	55
63	37	77	35	13	58	6	59
63	0	77	6	14	6	7	3
61	46	75	45	13	59	6	59½
61	20	75	26	14	6	7	3
60	58	74	50	13	52	6	56
58	50	72	45	13	55	6	57½
58	30	72	25	13	55	6	57½
58	15	72	10	13	55	6	57½
57	40	71	30	13	50	6	55
57	10	70	58	13	48	6	54
56	43	70	42	13	59	6	59½

Mean variation by the above nineteen observations,			6	58¼
Equation for change of declination,				+ 5
Variation by nineteen observations of August 15,			7	3¼
Ditto	six	6,	7	1
Ditto	five	1,	6	59⅘
Ditto	seven	July 31,	6	59$\frac{4}{7}$
Ditto	five	30,	7	5⅘
Ditto	seven	28,	7	0
Ditto	eight	27,	7	5½
Varian. by the mean of seven days, containing fifty-seven obs.			7	2

XII. *Magnetical Observations, made at* Cambridge. *By* STEPHEN SEWALL, *F. A. A.* Hancock *Professor of the Oriental Languages in the University.*

THESE observations were made at my house, with the accurate and elegant variation compass of *Nairne's* construction, belonging to the University, with which I was favoured by Professor *Williams*. The meridian-line, to which the instrument was applied, is presumed to be accurately true; no pains were spared to make it so.

Time.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
1782.	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″				° ′ ″
April 15								6 53									
16									6 56								
17								6 52									
18		6 44						6 52	6 47				6 45				
19		6 36						6 52									
20	6 37							6 54					6 45				
21																	
22	6 39																
23	6 43						6 59										
24		6 48					6 58					6 48					
25																	
26		6 49	6 41	6 51			6 55		7 3		6 52		6 54				
27																	
28																	
29			6 38	6 45	6 45	6 57	6 57	7 00*		6 55							
30		6 46	6 46			6 59	6 47	6 56			6 54		6 50				6 48‡
Mean.	6 39 40	6 44 36	6 41 40	6 48 00	6 45 00	6 58 00	6 55 12	6 54 09	6 55 20	6 55 00	6 53 00	6 48 00	6 48 30				6 48 00

6° 49′ 35″ Mean of the observations.

* Needle vibrating.

‡ Needle vibrating to 43′. Aurora Borealis.

Time.

Time.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
1782.	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
May 1				6 39		6 52			6 47	6 59		6 42					
2				6 40		6 43	6 48	6 51	6 54	6 49							
3	6 35		6 46			6 55	6 51			6 53							
4	6 41		6 41		6 54	6 50	6 58	7 08	6 54		6 53	6 46					
5																	
6	6 37		6 30		6 42		6 48										
7		6 50	6 39			6 55	6 55						6 37	6 48	6 58		
8	6 43	6 40	6 41					6 56								6 34	
9						6 56		6 53									
10	6 32					6 54	6 54		6 54				6 43			6 38‡	
11			6 39				6 50	6 50	6 55			6 52	6 40	6 48			
12									6 57				6 45	6 45		6 45	
13			6 40		6 51		6 56	6 52						6 42	6 42		
14	6 40	6 40	6 40	6 51	6 44	6 49	6 49	6 54	6 50	6 48	6 44	6 44		6 44	6 56	7 03	6 56
15		6 49	6 41	6 46	6 43	6 57	6 57	6 52	6 51			6 46	6 46	6 49		6 48	7 02
16		6 38	6 42	6 42		6 55	6 55	6 52			6 56		6 48	6 48		‖	
17		6 35	6 41				6 47	6 54				6 44	6 50			6 44	6 44
18	6 37	6 42	6 38			6 45	6 49	6 49						6 47	6 47	6 47	
19																	
20	6 30	6 37	6 33	6 35													
25		6 38	6 38	6 44		6 49	6 54	6 51	6 53	[illegible]	6 51			6 46		6 46	6 46
26							6 59	6 52				6 50	6 36			6 47	6 36
27	6 52*	6 44	6 42	6 51	6 56	6 49	6 51	6 55	6 47	6 51	6 51	6 47					
28			6 41	6 39												6 36	6 40§
29	6 42†	6 35	6 35	6 34		6 43	6 57	6 48		7 02	6 46	6 45					
30			6 35	6 39	6 43	6 47	6 53										
31													6 43				
Mean,	6 38 54	6 42 44	6 39 1[illegible]	6 42 11	6 48 17	6 50 36	6 52 50	6 53 08	6 52 12	6 43 4[illegible]	6 50 10	6 46 13	6 43 07	6 46 20	6 50 45	6 44 48	6 47 20

6° 46′ 30″ Mean of the observations.

* Needle vibrating. † Needle vibrating. ‡ Needle vibrating 10′. Small Aurora Borealis.
‖ Needle vibrating prevented an observation. § Small Aurora Borealis.

Time.

Time.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
1782.	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
June 1	6 39		6 45	6 47	6 43	6 46	6 54	6 52		6 55	6 49	6 45	6 45		6 40		
3			6 38		6 48	6 47	6 50	6 50	6 50	6 50	6 46	6 43					6 53
4				6 37	6 46	6 48	6 50	6 50	6 53	6 50		6 45†	6 44	6 44			
5			6 36		6 45	6 47	6 45	7 02	6 59	7 02	6 38	6 59	6 51	6 51			6 49§
6				6 37	6 43		6 45	6 50		6 52			6 46				6 48§
7				6 36		6 52	6 49	6 53	6 55				6 56‡	6 42	6 46	6 40	
8		6 41	6 46			6 48	6 49	6 49	6 49			6 41	6 44	6 38		6 51	
10			6 40		6 47	6 45	6 48	6 47	6 50	6 48				6 42	6 48	6 48	6 43
11	6 38		6 36	6 40	6 44	6 46	6 49	6 54			6 49		6 45	6 47			6 47
12	6 38	6 38	6 38	6 38	6 45	6 45	6 49	6 52	6 52	6 51	6 47*						
13	6 38		6 38	6 39	6 47	6 46	6 51	6 56	6 56	6 53	6 54	6 50		6 52		6 44§	
14			6 37			6 48	6 51	6 50					6 43‡				
15			6 33	6 43		6 47	6 49	7 01				6 50		6 46			
17			6 41	6 38		6 47	6 53		6 50		6 40		6 43				
18	6 37		6 38	6 38	6 38	6 44	6 46		6 48								
19	6 37		6 37	6 41		6 47		6 51	6 49								
28										6 49	6 56	6 43					
29			6 36			6 55	6 49					6 38		6 46			
Mean.	6 37 50	6 39 30	6 38 30	6 39 27	6 44 36	6 47 22	6 49 11	6 52 38	6 51 55	6 52 13	6 47 22	6 46 00	6 46 20	6 45 20	6 44 40	6 45 45	6 48 00

6° 45′ 41″ Mean of all the observations.

* Thunder-storm. † Thunder in the west. ‡ Needle vibrating. § Small Aurora Borealis.

Time.

Time.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
July 1	° ′ ″	° ′ ″	6°28′* ″	6°35′ ″	6°41′ ″	° ′ ″	6°49′ ″	6°51′ ″	6°51′	6°51′	6°51′ ″	6°51′ ″	6°51′ ″	6°44′ ″	° ′ ″	° ′ ″	
2			6 35	6 21	6 58†	6 40	6 49	6 54			6 46	6 50					
3	6 39	6 39	6 39	6 39	6 39	6 44	6 51	6 51	6 51	6 51	6 51	6 40					
4			6 32	6 48	6 41	6 47	6 48	6 48						6 40			
5			6 31			6 56	6 54						6 41	6 47			
6			6 36	6 36		6 55	6 47	6 47	6 56	6 52	6 41	6 41	6 41	6 41			
8			6 47	6 35													
10		6 28	6 37	6 42		6 48	6 55†	6 57†	6 44								
11	6 41	6 41	6 42	6 44	6 53	6 49	6 50	6 47	6 54							6 34	6 32
12			6 44	6 37	6 48	6 48	6 55	6 58	6 54	6 51				6 41		6 52†	6 52†
13			6 35	6 43	6 38	6 51	6 54	6 53	6 53	6 49							
15			6 34	6 47	6 41	6 47	6 50	6 54	6 48	6 49	6 43	6 41					
16		6 37	6 45	6 41	6 47	6 52	6 51	7 00	6 52	6 51	6 46	6 48	6 51	6 49			
17			6 38	6 44	6 49												
18					6 57	6 54	6 57	6 53	6 56				6 52			6 49	
19			6 38	6 41	6 43		6 51	7 00					6 53	6 50		6 50	6 47§
20						6 46	6 58										
22			6 39	6 42	6 53	6 50	6 50	6 56	6 53	6 51		6 48	6 56	6 56		6 47	
23			6 41	6 44	6 45	6 48	6 50	6 49	6 49	6 47		6 40	6 45			6 45	
24			6 29		6 45	6 52*	6 47*	6 58*	6 52		6 47	6 44		6 38	6 51	6 32	7 03‡
25			6 43	6 31	6 43	6 47	6 51	6 53	6 51		6 49	6 41	6 41	6 41	6 41	6 41	6 41
26				6 35	6 43	6 48	6 48	6 53	6 53	6 53		6 40	6 38	6 38		6 49	
27			6 34	6 38	6 41	6 49	6 54	6 54	6 52	6 46	6 42	6 44	6 44	6 44	6 44		
29			6 32	6 37	6 37	6 54	6 50	6 50	6 50					6 47		6 44	
30		6 33	6 38	6 42	6 45	6 45	6 48	6 48	6 48	6 51	6 45	6 45	6 45				
31			6 33	6 38	6 57	6 58	6 50	6 55	6 48	6 49			6 39	6 39			
Mean.	6 40 00	6 35 36	6 36 57	6 39 05	6 115 54	6 49 27	6 51 07	6 53 08	6 51 19	6 50 05	6 46 06	6 44 05	6 45 55	6 43 56	6 45 20	6 44 18	6 47 00

6° 45′ 15″ Mean of all the observations.

* Thunder-storm. † Needle vibrating. § Vibrating to 7° 03′. Aurora Borealis. ‡ 10¼h. 6° 34′.

Time.

Time.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.
1782.	° ′ ″		° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	
Aug. 1			6 39	6 39	6 39	6 41	6 44	6 48	6 46	6 48	6 42				6 48	6 40	
2			6 34	6 42	6 42	6 49	6 47	6 51	6 51	6 50	6 45	6 41					
3			6 41	6 41	6 47	6 47	6 49	6 49	6 51	6 51		6 47	6 44		6 40		
5			6 31	6 39	6 39	6 43	6 50	6 52	6 48	6 52	6 47						
6			6 37		6 45	6 50	6 53	7 01	6 49	6 47	6 46			6 46			
7	6 41		6 38	6 37		6 51	6 58	6 55	6 41		6 49	6 46		6 41			
8			6 36	6 42	6 42	6 46	6 55		6 54	6 48	6 52	6 47					
9			6 28*	6 47*	6 45*	6 55	6 50		6 53	6 51				6 45			
10			6 32	6 36	6 42	6 45	6 48		6 51		6 45		6 43				
12			6 35		6 40	6 42	6 47		6 53	6 48				6 38			
13			6 35		6 47	6 47	6 52	6 52	6 54	6 50	6 46					6 40	
14			6 31	6 41	6 41	6 52	6 45	6 52			6 49		6 49	6 49	6 49	6 49	
15			6 34		6 47												
17			6 37		6 44	6 47		6 46									
19			6 31	6 40	6 36	6 47	6 51	6 55	6 51	6 47	6 41	6 43	6 43				
20			6 38	6 38	6 46		6 54	6 48	6 53	6 43	6 43	6 43	6 43	6 43	6 43	6 35	
Mean	6 41 00		6 35 26	6 40 11	6 42 48	6 47 17	6 50 09	6 51 44	6 50 23	6 48 38	6 45 55	6 44 30	6 44 24	6 43 40	6 45 00	6 41 00	

6° 44′ 48″ Mean of all the observations.

The mean of all the observations, from May to August, makes the variation 6° 46′ 22″ W.

* Needle vibrating.

XIII. *An Historical Register of the Aurora Borealis, from August the 8th, 1781, to August 19, 1783.* By Caleb Gannett, *A. M. Rec. Sec. A. A.*

Aug. 8, 1781. AN Aurora Borealis appeared in a common form, from eight o'clock till after ten. A luminous arc extended horizontally from north-west to north-east. The height of the arc, about 25°. A thick dusky vapour lay below. A few small strice ascended from the body of light. At $10^{h.} 15'$, a column of light ascended from about north-north-west,—passed north of *Arcturus*, and crossing the meridian in the zenith, extended to the east, to about 30° of the horizon. Thus it remained for several minutes, and then moved slowly southward, till $10^{h.} 45'$, when it vanished.

Meteors appeared in great numbers, shooting, in general, from north-west to south-east.

22. An Aurora Borealis,—of little extent, and faint.

23. ditto, ditto.

Sept. 18. ditto, ditto.

19. Appeared an auroral segment, extending from north-north-west, nearly east, supported by a dark vapour. A second luminous segment soon appeared above the first,—a thick dusky vapour intervening between the two. Some strice proceeded from the uppermost segment, which appeared to curve directly towards the zenith. About ten o'clock, a column of light shot up from the east, and crossing the meridian north of the zenith, passed some degrees west of the meridian. At eleven o'clock, appeared a number of corruscations; after which, the whole declined, till an entire disappearance.

Sept.

Sept. 25. At $7^{h.}$ 30′, an auroral arc appeared. Its meridional height about 53°. At $7^{h.}$ 45′, ſtriæ proceeded from the arc towards the zenith—their colour, in general, white.——Thoſe ſtriæ, from being regular, ſoon appeared like broken ſheets of light. At $8^{h.}$ 10′, the various interrupted ſtriæ, riſing from weſt-ſouth-weſt to eaſt-ſouth-eaſt, concentered at about 10° ſouth of the zenith. Glades, diverging from that point, extended to 15° in length, in every direction. After remaining in this ſtate about ſeven minutes, the northward radii recoiled towards the centre. The whole phenomenon, from that time, decreaſed rapidly. At $8^{h.}$ 20′, nothing more than a common Aurora was viſible. The ſtriæ from weſt-north-weſt were very red, and attended with corruſcations. At $8^{h.}$ 26′, the height of the luminous arc not more than 40°. Two or three ſmall ſtriæ; alſo, very thin white corruſcations obſervable, whoſe horizontal extent was from weſt to north, and vertical to 10° ſouth of the zenith. At $8^{h.}$ 30′, corruſcations ceaſed, and the light in the north ſcarcely ſo much as to attract notice. At $8^{h.}$ 37′, the light increaſed.—Striæ began to aſcend from the eaſt, very red.—The general arc appeared to generate new arcs, which travelled ſouthward, till the uttermoſt reached the zenith at $8^{h.}$ 43′. Between the arcs, which were not quite regular, proper ſky appeared,—in ſome parts, 5° in width, in others 3°. At $8^{h.}$ 46′, regular ſtriæ aſcended from north-weſt to eaſt, to 5° ſouth of the zenith, and terminated in a ſegment of a circle, whoſe diameter was about 9°. A quantity of the vapour, in appearance like a ſmall, thin, white, irregular cloud, collected at about 6° ſouth of the fore-mentioned ſegment. At $8^{h.}$ 54′, the ſtriæ continued;—the ſegment, in which they terminate, enlarged.—From nine o'clock, a gradual decreaſe, till the whole diſappeared.

Oct.

Oct. 15. At $8^{h.} 16'$, a luminous arc commenced in a point within two or three degrees of the horizon, nearly east.—— Thence diverging, it passed about 8° south of *Pleiades*, and proceeding between the stars in *Andromeda's Shoulder* and those in his left arm, crossed the meridian at about 13° south of the zenith, and extended to about 20° west of the meridian. At 5° altitude, the light was vivid and strong. From that height the light became more faint, till it became imperceptible at the afore-mentioned distance west of the meridian. The whole advanced south slowly, and disappeared at $8^{h.} 33'$, Auroral light was visible also from north-west to north.

19. A small Aurora.

Nov. 13. Ditto.

14. Ditto.

15. Ditto.

19. An Aurora extended from north-west to north-east.— White, except a red spot in the north-east :—and in the north-west, red and yellow. Striæ,—numerous, but not long.

March 9, 1782. A small Aurora.

April 2. Ditto.

4. Ditto.

14. Ditto.

May 9. Ditto.

22. From an extensive Auroral arc, striæ proceeded, till they almost reached the zenith. Their motion, at first, regular, afterwards, flashing and quivering.

July 9. A small Aurora.

10. Ditto.

Aug. 26. An Aurora. Striæ,—white but not long.

Sept. 13. An Aurora continued through the night. Its horizontal extent, from west-south-west to north-east. Its complexion, white and vivid. Some striæ, though not numerous. In the west, the dusky vapour, near the horizon, appeared in two segments of a circle; one extending southward, the other northward.

14. An Aurora afforded a few striæ. One striæ, generated from the southern limit of the horizontal light, ascended almost to the zenith. It diverged very much in its ascent. After continuing at its greatest height for a minute or two, it subsided to about 50° altitude. At 10$^{h.}$ 30′, the lower part, at about 15° altitude, became detached from the light below, and in the form of a narrow glade, remained suspended for several minutes, and then vanished.

22. At ten o'clock, a yellow stria of Auroral light appeared single in the west-south-west, without any dusky vapour beneath it; but rising from about 20° above the horizon, out of a smoky haze, and ascending to 55° altitude. It continued bright a few minutes, and then became faint. Three small striæ, at a small distance west of the former. After a continuance of about a quarter of an hour, the whole disappeared.

29. A small Aurora.

30. An Aurora—Inconsiderable through the evening. At twelve o'clock, striæ were numerous, frequent, and their motion brisk and undulatory.

Oct. 2. A small Aurora.

9. Ditto.

10. Ditto.

26. Ditto.

Jan. 26, 1783. Ditto.

Feb.

Feb. 2. A ſmall Aurora.

21. Ditto.

27. Ditto. A few white ſtriæ.

March 2. Ditto.

9, Ditto.

27. Ditto.

29. An Aurora was viſible at the horizon, extending from north-weſt to nearly north-eaſt. The whole arc, included within thoſe limits to about 12° altitude, quite luminous. At $7^{h.}$ 20′, the uſual duſky appearance commenced at the horizon, and increaſed till it became about 15° altitude. Light proceeded from the upper part, not as from the periphery of a regular arc, but from different heights. Striæ, frequent and diſconnected, often appearing like rare white luminous clouds, varying their poſition and continually riſing, till $7^{h.}$ 50′ they reached the zenith. Striæ more prevalent, paſſing the zenith. At $8^{h.}$, appeared a detached bright Auroral cloud in the ſouth-eaſt, within about 30° of the horizon.—Another long ſimilar cloud in the ſouth-weſt, paſſing ſwiftly downward to the ſame diſtance from the horizon;—thence, with a quick motion, weſtward;—then vibrated from eaſt to weſt in an arc of ſeveral degrees. Each Auroral cloud frequently diſappeared in an inſtant, then revived with equal, or ſuperior, luſtre.—Thus they continued a few minutes, and then entirely vaniſhed. The ſtriæ, which were hitherto frequent and briſk, tho' irregular, appeared to collect at about 5° ſouth of the zenith, and there formed a large body of light.—Soon ſucceeded new ſhootings of ſtriæ,—ſtrong and regular; and below them, a frequent flaſhing of light. Between the ſtriæ and luminous glades was the ſame duſky appearance, as in the cloud near the horizon. At $8^{h.}$ 15′, a corona formed at about 3°

ſouth of the zenith, ſurrounding a ſmall unilluminated circle. Dilated ſtriæ proceeded from it in every direction. The corona ſoon changed its form, and became two ſegments of a circle, convex towards the centre of the corona. Radii proceeded nearly north and ſouth, diverging. Theſe preſently ceaſed. At 8$^{h.}$ 25′, faint glades of light remained near the zenith, entirely detached from a large body of light extending from weſt-north-weſt to nearly eaſt.—Theſe in a tremulous motion, and frequently ſhooting very nimbly with increaſed luſtre. At 8$^{h.}$ 40′, light ſhooting briſkly from eaſt-north-eaſt in their glades, a little ſouth of the zenith, to about 18° weſt. Several apparently compact ſpots of light near the zenith, below which, corruſcations were very briſk. Calm till 8$^{h.}$ 45′.—Wind then freſh from weſt. At 9$^{h.}$ 30′, the Aurora, for three quarters of an hour paſt, having been upon the decline, ſettling down into a general body of light of a dull appearance, without a very duſky cloud near the horizon,—now re-commenced in vivid ſtriæ from the top of a black arc, about 25° altitude. At 9$^{h.}$ 35′, the ſtriæ, from ſhooting very nimbly, became corruſcations,—paſſed conſiderably ſouth of the zenith, and continued ſeveral minutes in very quick vibrations. At 9$^{h.}$ 50′, no uniform duſky appearance near the horizon,—the light appearing in detached clouds from thence upwards, dancing and flaſhing to the zenith. At 10$^{h.}$ 15′, ſubſided into a general body of light.

March 30. A ſmall Aurora.

April 3. Appeared a number of Auroral ſpots. After a ſhort continuance, they vaniſhed. No other Auroral light viſible.

7. In the beginning of the evening, appeared a common white Aurora, forming an agreeable arc at about 20° altitude,

extending

extending from north-weſt to north-eaſt, ſupported by a thick duſky cloud, as uſual; through which ſeveral ſtars were plainly viſible, eſpecially one very near the horizon. At eight o'clock, ſtriæ began to ſhoot. From $8^{h.} 15'$ to $8^{h.} 30'$, the light ſhot into different forms, detached in large ſpots or clouds. At $8^{h.} 30'$, a column of light aroſe from weſt-north-weſt; and, paſſing about 15° north of *Procyon*, extended ſeveral degrees eaſt of the meridian. At the ſame time, another column aſcended from nearly eaſt, at a conſiderable diſtance from the horizon,—paſſing a few degrees ſouth of the other, and terminating a little weſt of the meridian. Thoſe parts of the heavens included between the Auroral clouds, had a ſimilar appearance with the duſky cloud, which uſually appears beneath an Auroral arc. Stars were very viſible in thoſe included parts. The two columns from eaſt and weſt, moved ſlowly ſouth a few minutes, and then diſappeared. Afterwards, the light decreaſed till nine o'clock, when it became an ordinary Aurora.

April 11. A ſmall Aurora.

27. Ditto.

May 13. An Aurora commenced in the beginning of the evening;—aſcended in ſtriæ;—afterwards changed into whitiſh clouds, very thin, and in detachments paſſed the zenith,—travelled ſouthward, and continued viſible within 20° of the horizon. It ſoon declined, and in a little time was reduced to a common Aurora.

29. A ſmall Aurora.

Aug. 1. Ditto.

16. Ditto.

19. Ditto.

XIV. *A comparative View of Thermometrical and Barometrical Obfervations, at* Cambridge. *By the Rev.* EDWARD WIGGLESWORTH, *S. T. P.* Hollis, *F. A. A.*

A comparative View of Thermometrical Obfervations.

	1780.				1781.				1782.				1783.			
	High.	Low.	Range.	Mean.	High.	Low.	Range.	Mean.	High.	Low.	Range.	Mean.	High.	Low.	Range.	Mean.
January,					48½	13	35½	32	46	2	44	25	44	0	44	27
February,					45	9	36	31	41	1	40	27	55	0:1½	56½	34
March,					50½	25	25½	37					59	13	46	36
April,					59	35	24	45					77	35	42	52
May,					77	41	36	58					77	46	31	59
June,	77	51	26		78	50	28	65					85	54	31	72
July,	89	66	23	75	86	65	21	74					91	62	29	72
Auguft,	92	62	30	76	85¼	63	22¼	72	84	58½	25½	72	88½	56½	32	70
September,	78	49	29	64	81	57	24	67	85¼	49½	35¾	65	72	45	27	60
October,	68	39	29	51					66	39½	26½	51	62	38	24	50
November,	57	25	32	38	54	21	33	36	52	20	32	38	53	19	34	36
December,	55	12	43	31	41	15	26	30	56	12	40	33	61	12	49	32

A

A comparative View of Barometrical Obſervations.

	1780.				1781.				1782.				1783.			
	Higheſt.	Loweſt.	Range.	Mean.	Higheſt.	Loweſt.	Range.	Mean.	Higheſt.	Loweſt.	Range.	Mean.	Higheſt.	Loweſt.	Range.	Mean.
January,					30 30	28 83	1 47	29 66	30 57	29 40	1 17	30 05	30 33	29 04	1 29	29 64
Feb.					30 16	29 06	1 10	29 66	30 55	29 39	1 16	29 97	30 34	29 20	1 14	29 85
March,					30 26	29 16	1 10	29 76					30 12	28 91	1 21	29 71
April,					30 18	28 96	1 22	29 64					30 30	29 40	0 90	29 86
May,					30 05	29 41	0 64	29 75					30 32	29 42	0 90	29 86
June,	30 09	29 19	0 90		30 03	29 32	0 71	29 76					30 27	29 52	0 75	29 86
July,	30 20	29 50	0 70		30 19	29 71	0 48	29 98					30 18	29 47	0 71	29 87
Auguſt,	30 13	29 61	0 52	29 90	30 27	29 66	0 61	30 00					30 20	29 49	0 71	29 87
Sept.	30 15	29 38	0 77	29 82	30 40	29 67	0 73	30 02	30 24	29 69	0 55	29 97	30 23	29 42	0 81	29 82
October,	30 25	29 64	0 61	29 98					30 24	29 42	0 82	29 82	30 29	28 98	1 31	29 74
Nov.	30 41	28 90	1 51	29 73	30 50	29 15	1 35	29 76	30 50	29 20	1 30	29 80	30 39	28 72	1 67	29 70
Dec.	30 27	28 83	1 44	29 75	30 37	29 00	1 37	29 75	30 30	29 04	1 26	29 76	30 25	28 68	1 57	29 68

XV. *Meteorological Obſervations at* Ipſwich, *in* 1781, 1782 *and* 1783. *Lat.* 42° 38′ 30″ N. *Long.* 70° 45′ W. *By the Reverend* MANASSEH CUTLER, *F. A. A. and M. S. and Member of the Philoſophical Society at* Philadelphia.

THE thermometer uſed in the following obſervations, was made by *Gilbert*, on *Farenheit's* ſcale, with a tube fourteen inches in length. It is placed in an entry-way, remote from fire or the rays of the ſun. The barometer is of the portable kind, made by *Hair*. The quantity of rain is meaſured by an ombrometer, made of tin, twelve inches ſquare at the mouth, the ſides of which are perpendicular. The rain falls through the mouth into a funnel, which conducts it into a reſervoir, where it is ſecured from evaporation; and is, afterwards, decanted off and meaſured in a three-inch cubic meaſure. It ſtands firmly ſecured, in an open ſituation, with the mouth about two feet from the ground. The quantity of water contained in ſnows, is generally aſcertained by taking the cubic meaſure of a column of ſnow, at its mean depth, from the ſurface to the bottom, and diſſolving it in the ombrometer. But as ſnows frequently fall one upon another, or are accompanied with rain, there is great difficulty in aſcertaining, with exactneſs, the quantity of water that falls during the winter.

In the account of diſeaſes, not every diſorder that occured, but only ſuch as were moſt prevalent, are inſerted. *Edward A. Holyoke*, M. D. favoured me with the account of diſeaſes in *Salem*; Dr. *Iſaac Spafford* with thoſe in *Beverly*, and Dr. *Eliſha Whitney* with thoſe in *Ipſwich*.

Days.	H.	Ther.	Wind.	Weather.
1	8	31	NW. SW.	Fair.
	1	38		
	10	40		
2	8	39	SW.	Fair.
	1	44		
	10	43		
3	8	37	N.	Cloudy and ſnow.
	1	36		
	10	33		
4	8	31	SW.	Clouds & ⊙ſhine.
	1	35		
	10	36		
5	8	39	SW. W.	Fair, pleaſant.
	1	49		
	10	42		
6	8	37	W. SW.	Fair, fine day.
	1	41		
	10	42		
7	8	40	SW. N.	Clouds and rain.
	1	41		
	9	36		
8	8	23	NW.	Fair.
	1	24		
	10	23		
9	8	18	NW.	Cloudy, ſnowed a little.
	1	23		
	10	26		
10	8	33	N. SE.	A little ſnow, then rainy and foggy.
	1	40		
	10	41		
11	8	39	W.	Fair, high wind.
	1	44		
	10	43		
12	8	40	W.	Fair.
	1	44		
	10	40		
13	8	36	NW.	Fair.
	1	37		
	10	35		
14	8	31	SE.	Snow P. M. & moſt of the night.
	1	35		
	9	37		
15	8	35	W.	Fair. About 5 inches of ſnow on the ground.
	1	38		
	10	33		
16	8	26	W. NW.	Clouds & ⊙ſhine.
	1	31		
	10	27		
17	8	21	NW.	Clouds & ⊙ſhine. In the evening Aurora Borealis.
	1	23		
	10	28		
18	8	21	NW.	Fair.
	1	27		
	10	28		
19	8	27	NW.	Fair.
	1	35		
	10	34		
20	8	27	N.	Cloudy.
	2	36		
	10	37		
21	8	36	NE.	Snow; rain; foggy.
	2	39		
	10	39		
22	8	36	NW.	⊙ſhine; clouds; ſnow.
	1	38		
	10	37		
23	8	31	NE. NW.	Snowed; wind very high.
	2	37		
	10	30		
24	8	29	WSW. W.	Clouds and ſnow. About 6 inches of ſnow on the ground.
	2	34		
	10	33		
25	8	31	NW.	Fair. Faint Aurora Borealis at night.
	1	35		
	10	31		
26	8	26	NW.	Fair, pleaſant.
	1	31		
	10	32		
27	8	27	N.	Cloudy; at night rain.
	2	32		
	9	36		
28	8	40	SW. W.	Fair, fine day.
	2	42		
	10	37		
29	8	32	SW.	Fair.
	1	37		
	10	37		
30	8	32	SW. NW.	Rain; fair; high wind. Faint Aurora Borealis.
	1	39		
	10	35		
31	8	28	NW.	Fair. A very faint Aurora Borealis.
	1	31		
	10	31		

Therm.		A. M.	Noon.	P. M.
	Higheſt,	40°	49°	43°
	Loweſt,	18	23	23
	Mean ſtat.	32	36	33

The month, in general, open and mild. The frequent ſmall ſnows that fell, ſoon melted. Some days as pleaſant as April.

Diſeaſes in *Ipſwich*; worm caſes, ſome fevers, frequent abſceſſes, cephalalgias, ophthalmias—Healthy.

Diſeaſes in *Salem*; ophthalmias, a few pleuriſies and peripneumonys, a few vomitings and purgings, and worm caſes.

Diſeaſes in *Beverly*; pleuritic and peripneumonic fevers, worm caſes, vomitings and purgings.

Days.	H.	Ther.	Wind.	Weather.
1	8	28	SW. S.	Cloudy, a little snow.
	1	33		
	10	36		
2	8	38	SSW. Calm.	Rain, foggy.
	1	40		
	10	41		
3	8	41	WNW. W.	Fair, a very fine day.
	1	45		
	10	37		
4	8	27	NE.	Mild sn. storm; snow fell 6 inches deep.
	1	31		
	10	30		
5	8	27	W.	Fair A. M. Rain in the evening.
	1	35		
	10	34		
6	8	31	NW.	Fair.
	1	35		
	10	32		
7	8	28	SW.	Very clear.
	1	32		
	10	33		
8	8	30	SW.	☉shine and clouds.
	1	35		
	10	36		
9	8	23	NW. SW.	Very cold wind. Ther. rem. out of doors, the mercury stood at 0, at ½ after 9 o'clock, A. M.
	1	20		
	10	21		
10	8	19	NE.	Severe snow storm; high winds; sno. much drifted, about 16 inches deep.
	1	22		
	10	20		
11	8	27	NW.	Fine fair day.
	1	24		
	10	23		
12	8	14	NW.	Fair.
	1	23		
	10	21		
13	8	19	W. SW.	Fair.
	1	28		
	10	32		
14	8	35	SW.	Fair.
	1	42		
	10	41		
15	8	39	W. NW.	Fair. At night Aurora Borealis.
	1	41		
	10	43		
16	8	41	S. SE.	Clouds; snow; ☉shine.
	1	38		
	10	37		
17	8	37	W. NW.	Thunder & lightning in the morn. clouds and ☉shine P. M.
	1	40		
	10	34		
18	8	26	NW.	Fair, very cold.
	1	28		
	10	29		
19	8	27	S.	Snow and rain.
	1	34		
	10	37		
20	7	34	NW.	Fair.
	1	32		
	10	27		
21	7	23	W.	Fair.
	1	31		
	10	32		
22	8	34	E. NW.	Snow & rain; snow fell about 6 inches deep.
	1	38		
	11	37		
23	8	35	NE.	Hail and rain.
	1	37		
	11	38		
24	7	36	SW. W.	Fair.
	1	40		
	11	39		
25	7	36	SW. W.	Fair.
	1	40		
	10	39		
26	7	32	W. NW.	Fair.
	2	34		
	10	33		
27	7	30	W. SW.	Cloudy.
	1	36		
	10	39		
28	8	40	NW.	Fair.
	1	44		
	10	38		

Thermometer.	A. M.	Noon.	P. M.
Highest,	41°	45°	43°
Lowest,	14	20	20
Mean stat.	30	34	33

The ground covered with snow during the month.

Diseases in *Ipswich*; some remittent and bilious fevers, pulmonary phithises—Very healthy.
Diseases in *Salem*; ophthalmias, chicken pox, abscesses, a few anginas, pleurisies, hæmæptoes.
Diseases in *Beverly*; slow remittent fevers, abscesses, rheumatisms.

Days.

Days.	H.	Ther.	Wind.	Weather.	Days.	H.	Ther.	Wind.	Weather.
	7	31				7	39		
1	1	32	N. SW.	⊙ shine ; clouds ; rain.	17	2	47	SW.	Fair.
	10	35				10	42		
	7	34				7	43		
2	2	37	E.	Clouds ; rain and hail.	18	2	45	NE.	Clouds ; rain ; ⊙ shine.
	10	38				10	43		
	7	38				8	40		
3	1	40	SW. W.	Fair ; wind high.	19	2	43	E. SW.	Rain ; wind high ; ⊙ shine.
	11	38				10	41		
	7	34				7	40		
4	1	38	NW.	Fair.	20	2	48	NW.	Fair ; high wind.
	10	35				10	36		
	8	31				7	37		
5	2	38	SW.	Cloudy, snow.	21	2	41	NW.	Fair ; wind high.
	10	37				10	40		
	7	39				7	36		
6	1	45	SW.	⊙ shine and clouds.	22	2	40	NW.	Fair.
	11	43				9	38		
	8	35				7	35		
7	1	32	NE.	A N.E. sn. stor. wind very high ; snow fell 4 inches deep.	23	2	37	S. E.	Rain ; snow ; misty.
	10	29				11	42		
	7	30				7	43		
8	1	32	NW.	Snow A. M. ⊙ shine and clouds.	24	2	50	W. N.	Fair.
	11	32				9	44		
	7	27				7	36		
9	1	36	NW. W.	Fair.	25	2	38	NW.	Fair.
	10	34				9	36		
	7	31				8	35		
10	1	39	NW. W.	Fair.	26	2	41	NW. SW.	Rain ; snow at night, fell 2 inches deep.
	10	38				9	39		
	7	34				7	36		
11	1	42	NW.	Fair.	27	2	39	NW.	Fair. Aur. Bor. at night ; a bri. glade of light from S.E. to N.W. across hemis.
	10	43				9	37		
	7	39				7	30		
12	1	46	W. SW.	Fair.	28	1	32	SE. N.	Snow & rain ; wind excessive high.
	11	42				9	33		
	7	37				7	32		
13	2	41	NW.	Fair.	29	1	35	N.	Squally, ⊙ shine. At night a faint Aurora Borealis.
	10	37				10	34		
	7	31				7	31		
14	1	37	SE.	Snow and rain.	30	1	30	NW.	Fair.
	11	39				11	41		
	7	40				7	36		
15	1	50	SW. NE.	⊙ shine ; rain, foggy.	31	2	43	NW.	Fair.
	11	47				10	41		
	7	46							
16	1	47	NW.	Fair.					
	11	42							

Them.		A.M.	Noon.	P.M.
	Highest,	46°	50°	47°
	Lowest,	27	32	29
	Mean stat.	36	40	38

The weather frequently cloudy and blustering, but no very violent storms. Frost nearly out of the ground at the close of the month.

Diseases in *Ipswich* ; bilious and peripneumonic fevers, palsies, worm cases.
Diseases in *Salem* ; anginas, pleurisies, cholics, worms.
Diseases in *Beverly* ; mixed fevers, chronic rheumatisms, worms, anginas.

Days.	H.	Ther.	Wind.	Weather.
1	6	37	NW. N.	Fair.
	2	45		
	9	45		
2	7	38	NE.	Violent ſtorms of rain, ſnow & hail; high wind.
	2	40		
	11	39		
3	7	38	N. NE.	Very high wind; ſome ſnow & rain.
	2	40		
	9	40		
4	7	37	NW. W.	Fair.
	2	43		
	10	40		
5	7	41	W.	Fair.
	2	52		
	10	50		
6	6	45	N. NE.	Fair.
	1	50		
	10	48		
7	7	45	NE.	Fair.
	2	49		
	10	46		
8	7	49	NE. SW.	Small rain.
	2	48		
	10	46		
9	7	41	WNW	Fair; exceſſive high wind.
	1	43		
	10	42		
10	8	41	SE. S.	Fair.
	2	50		
	10	46		
11	7	42	NE.	Very rainy.
	2	43		
	10	42		
12	7	42	W. SW.	Fair.
	2	49		
	11	45		
13	7	43	NW.	Cloudy.
	2	45		
	10	43		
14	8	39	NW.	Fair.
	2	45		
	10	42		
15	6	38	NW.	Fair.
	1	46		
	9	48		
16	7	42	NE.	Fair.
	2	49		
	10	44		
17	7	41	NE. SW.	☉ ſhine and clouds.
	2	46		
	9	45		
18	7	46	NW.	Fair.
	2	50		
	9	47		
19	7	45	SE. NE.	Rain.
	1	47		
	9	44		
20	7	42	NE.	Small rain.
	2	43		
	9	42		
21	7	45	N. NE.	☉ ſhine and clouds.
	2	49		
	9	47		
22	7	45	N. SE.	☉ ſhine and clouds; very high wind.
	1	49		
	10	47		
23	7	44	W. SW.	☉ ſhine and clouds.
	2	49		
	10	46		
24	7	43	SSE.	Rainy.
	2	49		
	9	46		
25	7	48	W.	Clouds and ☾ ſhine.
	1	51		
	10	55		
26	6	55	W.	Clouds and ☾ ſhine.
	2	57		
	9	56		
27	6	52	N.	Fair.
	1	54		
	9	47		
28	6	45	N. SW.	Fair.
	1	58		
	10	51		
29	6	48	SW.	Fair.
	2	56		
	11	54		
30	6	51	S.	Cloudy; foggy; rain.
	2	52		
	11	56		

Therm.		A.M.	Noon.	P.M.
	Higheſt,	55°	58°	56°
	Loweſt,	37	40	39
	Mean ſtat.	44	48	46

Very bluſtering and cold the greater part of the month. Vegetation very backward.

Diſeaſes in *Ipſwich*; pleuritic and peripneumonic fevers, bilious diſorders—Healthy in general.

Diſeaſes in *Salem*; pleuriſies, peripneumonics, coughs and colds, anginas, pulmonary phthiſos, hæmæptoes, worms, a few mild, putrid, ulcerated throats—Sickly for the ſeaſon.

Diſeaſes in *Beverly*; pleuriſies, peripneumonics, coughs, colds, anginas and hæmæptoes.

Days.

Days.	H.	Ther.	Barom.	Wind.	Weather.
1	6	54		W.	Fair.
	1	60			
	9	65			
2	7	50		SW.	⊙ſhine & clouds.
	1	62			
	9	60			
3	6	57		NW. W.	Fair.
	2	60			
	10	58			
4	7	50		NW. W.	Fair. Violent whirlwind from NW. to SE.
	1	55			
	11	51			
5	7	52		SW. E.	Fair.
	1	58			
	10	57			
6	6	53		S.	Fair; wind high.
	2	62			
	9	58			
7	6	55		ESE.	Clouds & ⊙ſhine; high wind.
	2	58			
	10	50			
8	7	47		NE.	Very rainy.
	2	48			
	11	47			
9	6	45		N.	Exceſſive rain—a very great quantity fell in 48 hours.
	1	44			
	10	43			
10	6	43		NE.	⊙ſhine and clouds.
	1	44			
	9	45			
11	6	42		NE.	Fair.
	1	54			
	9	52			
12	8	49		NE.	Clouds, ſmall rain.
	1	50			
	9	52			
13	6	49	29,96	NW.	Clouds and ⊙ſhine.
	1	54	97		
	9	52	98		
14	6	48	30,08	NW. SW.	Fair.
	2	63	29,98		
	11	58	82		
15	6	58	77	W.	Fair.
	1	67	51		
	10	67	50		
16	6	60	71	SW. E.	Clouds and ⊙ſhine.
	1	63	69		
	10	62	76		

Days.	H.	Ther.	Barom.	Wind.	Weather.
17	6	58	29,83	NW. E.	Rain, thunder and lightning.
	1	59	90		
	9	58	87		
18	6	56	90	NE.	⊙ſhine and clouds.
	1	62	91		
	10	57	93		
19	6	54	30,0	SW.	Fair.
	2	65	29,86		
	9	62	86		
20	6	58	89	W.	⊙ſhine; ſmall rain.
	1	67	54		
	10	69	46		
21	7	65	55	NW. NE.	Clouds and ⊙ſhine.
	2	61	60		
	10	66	66		
22	7	59	92	NE. SW.	Clouds and ⊙ſhine.
	2	60			
	10	56	30,21		
23	6	56	20	E. SE.	⊙ſhine and clouds.
	1	62	16		
	9	57	20		
24	6	55	20	NE.	⊙ſhine and clouds.
	1	61	15		
	10	53	10		
25	6	52	03	NE.	Very rainy.
	1	52	29,96		
	10	52	90		
26	6	51	90	W.	Pleaſant, fair.
	1	58	89		
	10	57	88		
27	6	57	91	SW.	Fair, a very fine day.
	1	66	86		
	10	65	90		
28	6	61	99	WSW.	Fair.
	1	77	65		
	10	71	80		
29	6	67	85	SW.	Clouds and ⊙ſhine.
	1	81	55		
	10	71	65		
30	6	68	85	SW.	⊙ſhine and clouds.
	1	74	67		
	10	68	80		
31	7	65	95	W.	Fair.
	1	65	30,05		
	10	63			

Therm.	A. M.	Noon.	P. M.
Higheſt,	68°	77°	71°
Loweſt,	42	44	43
Mean ſtat.	55	57	58

The month, in general, cold and wet. Vegetation very backward—graſs ſhort and thin—Indian corn planted much later than uſual.

Diſeaſes in *Ipſwich*; continued and remittent fevers, peripneumonies, rheumatiſms, palſies, worm caſes.
Diſeaſes in *Salem*; convulſions, vomitings and purgings, worms, pleuriſies, rheumatiſms, ſeveral mild dyſenteries, abſceſſes, coughs and hæmoptoes.
Diſeaſes in *Beverly*; pleuriſies, convulſions, worms, rheumatiſms.

Tt 3 Days.

Days.	H.	Ther.	Barom.	Wind.	Weather.
	7	61	30,01		
1	1	64	05	E.	Fair.
	10	61	09		
	6	61	05		
2	1	61	03	N.	☉ ſhine and clouds.
	10	67	01		
	6	58	05		
3	2	67	29,96	NW. E.	Fair.
	9	62	30		
	6	57	12		
4	2	63	06	N. E.	Fair.
	10	59	18		
	6	55	22		
5	2	64		SSE. S.	Fair.
	10	63			
	6	59			
6	2	67	01	NE.	Cloudy ; foggy.
	9	64	29,99		
	7	60	90		
7	1	58	62	ENE. NE.	Cold N.E. ſtorm, very rainy.
	9	54	69		
	6	51	60		
8	2	53	65	NE.	Rainy.
	10	53	63		
	6	53	61		
9	1	61	55	W.	Miſty.
	10	62	58		
	7	60	63		
10	1	69	54	WNW	☉ ſhine, clouds, thunder.
	9	65	64		
	6	63	79		
11	2	72	65	NW.	Fair.
	10	60	71		
	6	63	81		
12	1	75	59	SW.	Fair.
	9	73	53		
	6	68	58		
13	2	76	30	SW.	☉ ſhine and clouds.
	9	73			
	6	69	50		
14	1	77	49	SW.	☉ ſhine and clouds ; very ſultry.
	10	73	44		
	6	70	51		
15	2	67	51	N.	Small rain.
	10	66	56		
	6	61	29,73		
16	2	68	69	NW.	Fair.
	10	64	77		
	7	65	79		
17	1	69	66	W. SW.	☉ ſhine ; clouds ; ſmall rain.
	10	67	72		
	6	65	73		
18	2	73	52	S.	Cloudy ; rain.
	9	68	50		
	6	66	41		
19	1	71	27	WSW.	☉ ſhine ; clouds ; rain ; wind very high.
	10	66	61		
	6	63	72		
20	1	68	65	NW.	Fair, wind high ; Aurora Borealis.
	9	66	72		
	6	61	88		
21	1	70	68	W.	☉ ſhine and clouds ; at night, thunder and lightning ; rain.
	9	67			
	6	60	84		
22	2	74		NW. W.	Fair ; cool ; very windy.
	9	72			
	6	64	57		
23	1	68		NW. W.	Fair, windy.
	10	66			
	6	62	80		
24	1	70		NW. W.	Fair ; cool air ; very drying wind.
	10	66	74		
	7	67	80		
25	1	74		SW.	Fair ; clouds ; thunder & light. windy.
	10	69	81		
	6	64			
26	1	69		SW. NE.	☉ ſhine ; clouds ; ſmall rain.
	10	66	90		
	7	63	82		
27	2	63	80	NE.	Very rainy, wind high.
	9	60	85		
	6	58	84		
28	1	60	82	N.	Miſty.
	10	60	82		
	6	60	82		
29	2	69	70	SE. SW.	Miſty ; ſmall rain.
	10	69	72		
	6	67	78		
30	2	77	62	SW.	Fair ; a very fine day.
	10	69	81		

Therm.	A.M.	Noon.	P.M.
Higheſt,	70°	77°	73°
Loweſt,	51	53	53
Mean ſtat.	62	68	62

Barom.	A.M.	Noon.	P.M.
	30, 22	30, 06	30, 18
	29, 41	29, 27	29, 44
	29, 78	29, 69	29, 76

Plentiful rains. Grain, in general, very fine. Indian corn low for the ſeaſon.—Very little thunder and lightning.

Diſeaſes in *Ipſwich* ; pleuriſies, peripneumonies, worms, abſceſſes, rheumatiſms.
Diſeaſes in *Salem* ; fevers, diarrhæas, vomitings with purgings, pleuriſies, ophthalmias, abſceſſes, rheumatiſms.
Diſeaſes in *Beverly* ; much the ſame as in Salem.

Days.

Days.	H.	Ther.	Barom.	Wind.	Weather.
1	7	72	29,76	NE. SW.	Fair, a fine day.
	1	75	70		
	10	72	77		
2	6	69	84	W.	☉ſhine ; P. M. a thunder ſhower.
	1	77	60		
	9	72	70		
3	6	68	80	NW. SW.	Fair.
	1	76	62		
	10	70	76		
4	6	69	82	NNW.	☉ſhine and clouds ; briſk air.
	1	79	62		
	9	72	91		
5	7	68	30,00	NW. W.	Fair, ſultry.
	1	81	29,70		
	9	79	64		
6	6	75	85	N.	Smoky, cool breeze.
	1	74	85		
	9	69	90		
7	6	67	90	W.	Fair, ſmoky and ſultry.
	1	81	58		
	9	80	52		
8	6	76	59	WSW.	Hazy, very ſultry.
	1	86	28		
	10	82	19		
9	6	79	28	NW.	Fair.
	1	83	19		
	10	78	45		
10	6	74	72	NNE.	☉ſhine and clouds ; cool air.
	10	66	95		
11	6	67	96	NNE.	Miſty morn; ☉ſhine; cool air.
	2	69	97		
	10	66	30,05		
12	7	65	06	NNW NE.	☉ſhine and clouds.
	2	70			
	10	66	00		
13	7	65	29,96	SSW.	Fair, very ſultry and dry.
	1	76	68		
	9	76	76		
14	6	70	82	W. SW.	Cloudy ; high wind.
	1	80	51		
	10	76	54		
15	6	76	50	SW. N.	Plentiful rain.
	1	75	24		
	10	74	59		
16	7	73	62	N.	Hazy.
	1	74	56		
	10	70	62		

Days.	H.	Ther.	Barom.	Wind.	Weather.
17	7	70	29,60	NNW. N.	Miſt and rain.
	1	70	52		
	10	69	53		
18	7	70	56	W.	Fair, fine day.
	2	81	36		
	9	78	41		
19	7	69	67	NE.	Very rainy.
	1	68	66		
	9	65	71		
20	7	63	83	NW. SE.	Fair.
	2	70	72		
	9	77	85		
21	7	66	90	SE.	Fair.
	2	73	74		
	9	70	86		
22	7	66	95	WNW. S.	☉ſhine and clouds.
	3	75	76		
	10	71	81		
23	6	68	84	W.	☉ſhine and clouds.
	1	79	50		
	10	74	58		
24	6	70	61	SSW. S.	☉ſhine and clouds; a ſmall ſprinkling of rain.
	2	81	26		
	10	73	40		
25	6	71	48	WNW	Cloudy, ſmoky air.
	1	75	45		
	10	73	53		
26	7	69	72	NW. W.	☉ſhine and clouds.
	2	74	62		
	10	69	80		
27	6	69	90	N.	☉ſhine and clouds.
	2	74	80		
	10	70	82		
28	6	67	88	W. S.	☉ſhine and clouds.
	2	77	62		
	10	72	71		
29	7	68	78	SW.	Fair morn, cloudy afternoon.
	1	[illegible]	64		
	10	73	61		
30	6	72	60	W.	☉ſhine&clouds. P.M. a plentiful ſhow. of ra. without thun. or ligh.
	1	80	44		
	10	75	46		
31	6	72	54	WNW W.	☉ſhine and clouds.
	2	79	36		
	10	75	41		

	Therm. A.M.	Therm. Noon.	Therm. P.M.	Barom. A.M.	Barom. Noon.	Barom. P.M.
High.	79°	86°	82°	30,06	29.97	30,05
Low.	63	68	65	29,28	29,19	29,19
M. ſtat.	70	76	72	29,75	29,57	29,68

The firſt part of the month very hot and dry ; the hot weather continued with repeated rains and great dews. Engliſh grain, in general, very fine. Rye conſiderably injured by blaſt or mildew. Siberian wheat, which was ſowed in large quantities, almoſt totally ruined. Engliſh hay, plenty. Indian corn, and flax, very good. Scarce any thunder and lightning.

Diſeaſes in *Ipſwich* ; bilious complaints, anaſarcas, worm caſes, a few fevers—Very healthy.

Diſeaſes in *Salem* ; diarrhæas vomitings, dyſenteries, anaſarcas, ophthalmias.

Diſeaſes in *Beverly* ; alvine fluxes, remittent and putrid fevers.

Days

Days.	H.	Ther.	Barom.	Wind.	Weather.
1	7	71	29,56	NNE.	Fair ; very ſmoky P. M.
	1	74	53	NE.	
	9	71	68		
2	7	70	70	NNE.	Fair, ſmoky.
	1	75	63	SE.	
	9	69	81		
3	7	65	90	E.	Foggy morn ; fair ; at night rain.
	1	74	70	SE.	
	9	70	80		
4	7	70	80	SE.	⊙ ſhine and clouds, ſultry.
	1	77	65	SW.	
	10	76	68		
5	7	72	84	WNW.	⊙ ſhine and clouds.
	2	80	60	SW.	
	10	74	75		
6	6	74	74	NW.	Fair ; very ſultry. A very curious Aur. Borealis at night.
	1	82	51	SW.	
	10	78	50		
7	6	74	57	SW.	Fair, ſtill very ſultry.
	2	82	36		
	10	79	85		
8	7	76	85	W.	Fair; ther. out doors, and in the ſun, merc. rang. at 108° at 5 P. M.
	2	87	06	SW.	
	10	83	11		
9	6	75	39	W.	Fair, briſk air.
	2	80		SW.	
	10	77	41		
10	7	71	65	NW.	Fair ; briſk wind ; cool ; a very ſudden change in the weather
	1	72	62		
	9	69	90		
11	7	64	30,05	N.	Wind briſk ; ⊙ ſhine and clouds.
	1	67	02	NW.	
	10	65	04		
12	7	61	38	E.	Cool, very ſmoky, clouds and ⊙ ſhine.
	1	70		NE.	
	9	67	29,84		
13	7	69	46	SW.	Plentiful rain laſt night & this morn ; clouds and ⊙ ſhine.
	1	71	43	W.	
	10	69	52		
14	6	65	73	NW.	⊙ ſhine ; Aurora Borealis at night.
	1	60	72		
	10	64	90		
15	7	62	30,06	NNW.	Fair.
	1	69	29,95		
	9	67	30,07		
16	6	62	14	E.	Foggy morn. ⊙ ſhine
	2	70	02	SE.	
	10	65	10		
17	7	61	30,14	W.	Clouds and ⊙ ſhine.
	2	68	00	SW.	
	9	67	00		
18	7	65	06	SW.	⊙ ſhine.
	1	71	29,93	E.	
	10	67	30,00		
19	6	66	29,93	E.	⊙ ſhine and clouds, rain afternoon.
	1	73	73		
	9	70	72		
20	7	69	50	NNW.	Fair. Aur. Borealis which continued thro' the night.
	2	75	44		
	9	70	70		
21	6	65	90	WNW.	Very clear. Aurora Borealis at night:
	2	74	70		
	9	71	72		
22	7	67	91	SW.	Fair. Aur. Borealis at night.
	2	78	60		
	10	72	74		
23	1	71	79	S.	Cloudy.
	2	75	59		
	10	73	62		
24	7	72	70	NNW.	Clouds and ⊙ ſhine.
	1	74	65		
	10	70	84		
25	7	65	96	N.	Clouds and ⊙ ſhine.
	1	69	88		
	9	65	95		
26	6	64	94	NNW.	⊙ ſhine, clouds, rain at night.
	2	68	76		
	9	68	72		
27	6	78	62	WNW.	Foggy morn; ⊙ ſhine; ſhower at night.
	2	72	56	N.	
	9	69	69		
28	6	62	86	NW.	Fair.
	1	73		SW.	
	9	68	74		
29	6	68	69	SW.	Clouds and ⊙ ſhine.
	1	72			
	9	71	78		
30	7	69	30,07	SW.	Clouds and ⊙ ſhine.
	1	72	29,80		
	10	71	77		
31	6	71	69	S.	Clouds ; plentiful ſhower.
	1	76	50		
	10	69	73		

	Therm. A.M.	Therm. Noon.	Therm. P.M.	Barom. A. M.	Barom. Noon.	Barom. P. M.
Hig.	76°	87°	83°	30,14	30,02	30,10
Low.	61	67	64	29,39	29,06	29,11
M. ſtat.	68	74	70	29,81	29,66	29,67

The air frequently much loaded with vapour. Not an inſtance of thunder and lightning. Salt graſs well grown. Garden eſculents very plenty.

Diſeaſes in *Ipſwich* ; diarrhœas dyſenteries, cardialgias, anginas—Healthy.
Diſeaſes in *Salem* ; vomitings and purgings, coughs, abſceſſes, fevers, choleras, abortions.
Diſeaſes in *Beverly* ; putrid fevers, diarrhœas, and dyſenteries.

Days.

Days.	H.	Ther.	Barom.	Wind.	Weather.
	6	63	29,93		
1	2	69	82	WNW	Fair.
	9	66	90		
	6	61	95		
2	1	68	72	WNW. SW.	⊙ ſhine and clouds.
	10	68	64		
	6	66	69		
3	1	76	44	SW.	⊙ ſhine and clouds.
	9	72	45		
	7	73	40		
4	2	81	25	SW. NW.	⊙ ſhine ; cloudy ; ſmall rain.
	9	72	62		
	6	65	30,00		
5	1	70		NW.	⊙ ſhine and clouds.
	9	63	27		
	7	59	34		
6	1	67	15	NW. W.	⊙ ſhine and clouds.
	9	65	10		
	7	65	00		
7	1	74	29,55	S. SW.	⊙ ſhine ; clouds ; rain at night with high wind.
	11	73	42		
	7	70	58		
8	1	66	80	WNW. NW.	Fair, windy.
	10	61	30,14		
	8	58	14		
9	2	64	20	NW.	Clear.
	9	62	28		
	7	61	25		
10	2	65	09	SW.	Fair.
	9	62	07		
	7	62	29,92		
11	1	69	60	SSW.	Clouds, rain.
	10	69	42		
	7	63	69		
12	1	64	70	SW.	Clouds, ⊙ ſhine.
	9	62	83		
	7	60	93		
13	2	66	82	W. E.	⊙ ſhine and clouds.
	10	62	92		
	7	57	30,07		
14	1	69	29,92	W.	Fair.
	10	65	30,05		
	7	62	08		
15	1	74	29,76	W.	Fair.
	10	69	80		
	7	63	29,77		
16	1	77	40	W.	⊙ ſhine ; clouds ; windy ; rain at night.
	10	74	47		
	6	66	82		
17	1	61	98	NE. E.	⊙ ſhine and clouds.
	10	56	30,03		
	7	58	29,93		
18	1	60	70	E. W.	Very rainy, with high wind; fair; bright Au. Borealis at night.
	9	61	62		
	6	58	72		
19	2	71	48	W. SW.	Very clear.
	10	70	50		
	6	67	63		
20	1	59	96	NW. NNW.	Cloudy, a little rain.
	9	57	30,01		
	7	55	04		
21	1	54	29,99	NW. N.	Cloudy, rain, fair.
	10	51	30,07		
	6	47	21		
22	2	53	13	NW.	Very ſmall froſt in the morn. ⊙ ſhine and clouds; windy.
	10	54	20		
	7	50	25		
23	2	63	29,93	W.	Fair.
	9	63	94		
	6	57	30,10		
24	1	68	29,91	WNW.	Fair.
	9	63	30,00		
	6	59	01		
25	2	74	29,50	SW.	Fair, fine day. Aur. Borealis at night.
	9	70	60		
	6	64	67		
26	1	62	71	WNW.	Fair, wind very high.
	9	57	94		
	7	52	98		
27	1	58	81	NW. WSW.	⊙ ſhine and clouds : rain at night.
	10	57	66		
	7	56	61		
28	1	65	47	NW.	Fair, fine day.
	10	60	65		
	7	55	74		
29	2	60	60	NNW. NE.	⊙ ſhine and clouds.
	9	60	54		
	7	58	59		
30	2	58	74	WNW. NNW.	⊙ ſhine and clouds.
	9	55	30,03		

Therm.	A.M.	Noon.	P.M.
Higheſt,	78°	77°	77°
Loweſt,	47	53	51
Mean ſtat.	60	66	63

Barom.	A.M.	Noon.	P.M.
Higheſt	30, 34	30, 20	30, 20
Loweſt	29, 40	29, 25	29, 48
Mean	29, 90	29, 76	29, 84

Very little rain. Fine weather for ripening Indian corn, and making ſalt hay, of which there are good crops. Garden-fruit plenty.

Diſeaſes in *Ipſwich* ; diarrhœas, dyſenteries, vomitings—Very healthy.
Diſeaſes in *Salem* ; dyſenteries, vomitings and purgings, choleras, abſceſſes, diarrhœas.
Diſeaſes in *Beverly* ; dyſenteries and diarrhœas, low fevers.

Days.	H.	Ther	Barom.	Wind.	Weather.
1	8	48	30,26	NNW. SW.	Fair ; a ſmall froſt this morning.
	2	54	20		
	10	52	20		
2	8	55	24	SE.	☉ ſhine and clouds ; rain at night.
	2	61	29,98		
	9	60	92		
3	7	59	90	NW.	Foggy ; fair ; ſhower at 5 o'clock.
	1	62	83		
	9	58	30,00		
4	7	49	31	NW.	ſhine and clouds.
	2	50	40		
	9	48	55		
5	7	40	68	W. SW.	Fair. Water a little frozen this morn.
	1	49	45		
	10	52	30		
6	7	51	25	W.	Fair.
	2	60	29,98		
	9	55	30,06		
7	7	53	24	N.	Clouds and briſk wind.
	1	53	36		
	9	51	46		
8	8	43	58	NNW. SW.	Fair. Small Aur. Borealis at night.
	2	53	38		
	10	48	28		
9	7	46	14	NW.	Fair.
	1	59	29,90		
	10	59	97		
10	7	52	30,06	W. SW.	Fair.
	1	63	29,80		
	9	66	76		
11	7	61		W. SW.	Fair.
	2	70			
	9	68	74		
12	8	63	80	SW.	Several ſhowers ; ſome thun. & ligh.
	2	72	55		
	9	69	52		
13	7	63	49	SW. W.	☉ ſhine, clouds ; rain P.M. with thun. and ligh. & high wind.
	2	69	17		
	9	67	20		
14	7	50	65	WNW.	Clouds and ☾ ſhine.
	1	54	72		
	9	59	82		
15	7	56	95	SW.	Fair ; at night a very curious Aur. Bor.
	2	69	83		
	11	61	30,00		
16	7	60	00	SW.	☉ ſhine and clouds ; very briſk wind.
	1	68	29,75		
	10	65	63		
17	7	57	29,80	WSW. W.	Rainy morning, fair.
	1	51	87		
	10	51	94		
18	7	46	30,01	NNE. NE.	Clouds ; rain P.M. & thunder at night.
	1	52	29,96		
	10	51	30,00		
19	7	49	07	NW. NE.	Clouds and ☉ ſhine. Faint Au. Bor. at nig.
	2	51	03		
	11	46	13		
20	7	44	06	SW.	☉ ſhine & clouds ; at night thun. & light.
	2	50	29,73		
	10	56	59		
21	7	54	57	WSW.	☉ ſhine and clouds, fine day.
	2	56	48		
	10	54	66		
22	8	51	95	N.W.	☉ ſhine and clouds.
	1	53	96		
	10	50	30,19		
23	7	44	37	NW. E.	☉ ſhine and clouds.
	1	48	29		
	10	48	27		
24	7	49	06	SSW. WNW.	Clouds, rain aftern.
	1	57	29,67		
	10	54	61		
25	7	46	94	WNW.	Fair, fine day.
	2	49	94		
	10	45	30,14		
26	7	44	14	N. NE.	Clouds, rainy aftern.
	2	48	05		
	10	51	29,92		
27	7	49	30,10	NNW.	Clouds and ☉ ſhine.
	2	54	13		
	10	50	32		
28	7	46	46	N.	Clouds and ☉ ſhine.
	2	49	40		
	8	47	36		
29	7	45	22	NW. N.	Moderate rain.
	2	48	00		
	9	45	29,95		
30	8	42	92	W.	Fair, briſk wind.
	1	47	82		
	10	45	93		
31	7	40	30,02	SW.	Fair, fine day.
	2	57	29,87		
	9	52	94		

	Therm. A.M.	Therm. Noon.	Therm. P.M.	Barom. A.M.	Barom. Noon.	Barom. P.M.
Hig.	63°	72°	69°	30,68	30,45	30,55
Low.	40	47	45	29,49	29,17	29,20
M. ſtat.	50	56	54	30,01	29,93	29,97

More thunder and lightning in this month than during the whole ſummer. Several froſts ; but many of the more hardy flowers ſtill remain uninjured. Garden eſculents plenty. Indian corn well ripened, and a good crop.

Diſeaſes in *Ipſwich* ; a very few dyſenteries and diarrhœas, low fevers—Very healthy.
Diſeaſes in *Salem* ; dyſenteries, vomitings and purgings, choleras, abſceſſes, diarrhœas, fevers, abortions.
Diſeaſes in *Beverly* ; bilious cholics ; ſome nervous fevers.

Days.	H.	Ther.	Barom.	Wind.	Weather.
1	8	48	30,04	N.	Cloudy ; very great quantity of rain at night ; wind high.
	2	51	29,93		
	10	53	66		
2	7	52	55	SW. E.	Miſty ; at night very rainy.
	1	54	60		
	9	53	70		
3	8	50	60	N.	Very rainy, high wind.
	1	49	51		
	10	48	60		
4	7	45	63	NW.	Cloudy.
	1	46	62		
	9	46	71		
5	7	41	73	NW.	Bluſtering & ſqually.
	1	40	71		
	10	40	72		
6	7	39	74	NW.	Cloudy & bluſtering.
	2	43	71		
	10	44	75		
7	9	46	72	NW.	Fair and very pleaſant.
	1	47	62		
	10	44	84		
8	7	40	81	W. NW.	Very bluſtering and ſqually.
	1	43	70		
	10	40	86		
9	9	35	97	NW.	Very chilly and bluſtering.
	1	36	92		
	9	33	92		
10	8	31	30,0[illegible]	NW.	Fair, windy and chilly.
	1	36	02		
	10	37	10		
11	8	33	12	NW.	Fair.
	1	35	10		
	9	37	03		
12	8	35		NE.	Stormy.
	1	40	29,83		
	10	40	79		
13	9	38	83	NNE.	Cloudy and very chilly.
	1	40	93		
	10	39			
14	8	38	30,7	NNE.	Cloudy.
	2	39	10		
	10	39	12		
15	8	37	17	NW.	Cloudy.
	2	40	10		
	11	37	30		
16	8	35	30,40	WNW.	Fair, Aur. Borealis at night.
	2	41	32		
	10	40	35		
17	8	37	33	SSE. NE.	☉ ſhine and clouds.
	1	40	23		
	9	41	07		
18	8	42	29,90	N. NW.	Clouds and ☉ſhine.
	1	42	92		
	9	42	30,03		
19	8	39	07	W. WSW.	Fair. Small Aurora Borealis at night.
	2	44	29,95		
	11	44	30,07		
20	8	35	26	NW.	☉ ſhine and clouds.
	1	36	28		
	10	35	50		
21	8	30	55	NW. NE.	Cloudy : at night ſnow, which fell about 6 inches deep.
	2	35	36		
	9	35	21		
22	8	32	29,92	NW. WSW.	Clouds and ☉ſhine.
	1	34	86		
	10	34	86		
23	8	32	30,16	W.	Fair.
	2	32	30		
	10	29	58		
24	9	23	84	NW.	Fair.
	2	29	80		
	10	29	80		
25	8	27	70	SW.	Cloudy ; very rainy night.
	1	33	48		
	9	40	07		
26	8	40	29,33	SSE. NW.	Cloudy, rain.
	2	45	40		
	10	35	30,02		
27	8	26	26	NW.	Fair, briſk wind.
	1	30	36		
	11	32	50		
28	8	26	62	N. NE.	Cloudy ; wind high ; at night very rainy.
	1	33	52		
	11	37	23		
29	8	43	29,50	E. NW.	Rainy & bluſtering.
	2	43	41		
	11	37	67		
30	8	34	96	W.	Fair and pleaſant.
	1	39	30,06		
	10	38	22		

Therm.		A. M.	Noon.	P. M.
	Higheſt,	52°	54°	53°
	Loweſt,	23	29	29
	Mean ſtat.	37	40	39

Barom.	A. M.	Noon.	P. M.
	30,84	30,80	30,80
	29,33	29,40	29,60
	30,03	29,99	30,01

The greater part of this month very windy, cold and ſtormy.

Diſeaſes in *Ipſwich* ; ſome low fevers, coughs and colds.
Diſeaſes in *Salem* ; pleuriſies, abſceſſes, anaſarcas, coughs, ophthalmias.
Diſeaſes in *Beverly* ; cholics, coughs, ſome febrile complaints—Healthy.

Days.

Days.	H.	Ther.	Barom.	Wind.	Weather.
1	8	36	30,30	NNW.	☉ ſhine and clouds.
	2	41	23	NE.	
	10	41	25		
2	8	38	20	NNW.	☉ ſhine and clouds, very bluſtering.
	1	40	14		
	10	39	25		
3	9	37	17	NNW.	Sprinkling of ſnow, and then rain.
	1	37	14		
	10	38	20		
4	8	34	33	WNW.	☉ ſhine and clouds.
	2	41	28		
	10	40	21		
5	8	40	29,73	NE.	Very ſevere ſtorm of rain, with high wind.
	2	41	41	NW.	
	11	38	62		
6	8	35	82	W.	☉ ſhine & clouds.
	1	36	82		
	11	38	80		
7	9	37	70	N.	A ſprinkling of ſnow laſt night.
	1	38	64	NW.	
	11	38	80		
8	8	33	30,03	W.	☉ ſhine & clouds.
	2	34	03		
	11	37	23		
9	8	31	26	W.	☉ ſhine and clouds; ſnow at night.
	1	34	17		
	10	36	04		
10	8	36	29,46	NNE.	Snow, rain & hail.
	1	35	30	W.	
	10	31	55		
11	8	27	72	WSW.	Fair. Aurora Borealis at night.
	2	32	68		
	11	30	74		
12	8	27	68	SW.	☉ ſhine and clouds.
	2	30	60		
	11	31	70		
13	8	29	72	SW.	Fair and pleaſant.
	2	34	70		
	9	37	80		
14	8	31	95	SW.	Fair, pleaſant.
	1	34	91		
	10	33	96		
15	8	27	98	W.	Fair.
	2	31	90		
	10	30	30,00		
16	8	22	18	WNW.	Clouds, ſprinkling of ſnow at night.
	2	26		N.	
	10	29	11		
17	8	21	30,30	NW.	☉ ſhine and clouds.
	2	26			
	9	31	40		
18	8	29	47	NNW.	☉ ſhine and clouds.
	2	30	67	NW.	
	9	27	70		
19	9	26	74	W.	Clouds and ☉ ſhine.
	2	31	57	S.	
	10	33	47		
20	8	37	29,81	SE.	Fog and miſt. Moſt of the ſnow gone at night.
	1	41	50	NW.	
	11	40	80		
21	9	31	30,35	NW.	Fair.
	1	30	50		
	11	28	72		
22	8	24	70	W.	Fair.
	1	27	60	SW.	
	10	30	50		
23	8	28	48	NW.	Fair.
	1	35	41		
	9	36	52		
24	8	28	69	N.	Cloudy & bluſtering.
	2	27	66		
	9	24	62		
25	8	22	70	NW.	Fair.
	2	26	69		
	11	24	78		
26	8	21	78	WNW.	Fair.
	1	26	64	W.	
	11	32	45		
27	9	30	30	SW.	Cloudy and miſty.
	1	32	20		
	10	36	04		
28	8	35	29,80	N.	Very rainy.
	2	38	24	NE.	
	11	37	60		
29	8	35	82	S.	Small quantity of ſnow.
	2	38	40	W.	
	10	38	40		
30	8	34	30,20	WNW.	Fair and pleaſant.
	1	37	26		
	10	35	44		
31	8	32	40	NNW.	Snow and rain; foggy at night.
	2	36	10	SE.	
	11	38	29,73		

	Therm. A.M.	Therm. Noon.	Therm. P.M.	Barom. A.M.	Barom. Noon.	Barom. P.M.
Hig.	40°	41°	40°	30,78	30,69	30,78
Low.	20	26	24	29,46	29,24	29,40
M. ſtat.	30	34	34	30,15	30,01	30,11

The ground covered with a ſmall quantity of ſnow during the month; but not more than three or four inches deep at any one time.

Diſeaſes in *Ipſwich*; colds, abſceſſes, coughs, pulmonary conſumptions.
Diſeaſes in *Salem*; pleuriſies, catarrhal fevers, anginas, abſceſſes, coughs, cholics, anaſarcas,
Diſeaſes in *Beverly*; chronic rheumatiſms, bilious cholics.

Thermometer,

1781.	Thermometer. Greateſt Height.	Leaſt Height.	Mean Height.	Barometer. Greateſt Height.	Leaſt Height.	Mean Height.
January,	49	18	34			
February,	45	14	32			
March,	50	24	38			
April,	58	37	46			
May,	77	42	57			
June,	77	51	64	30, 22	29, 27	29, 74
July,	86	63	73	30, 06	29, 19	29, 67
Auguſt,	87	61	71	30, 15	29, 06	29, 74
September,	77	47	69	30, 34	29, 25	29, 83
October,	72	40	53	30, 68	29, 17	29, 97
November,	54	23	39	30, 84	29, 33	30, 01
December,	41	20	33	30, 78	29, 24	30, 09
Whole Year,	87	14	51			

1782.

JANUARY.

	Therm. A. M.	Noon.	P. M.	Barom. A. M.	Noon.	P. M.
Higheſt,	44	45	44	30, 88	30, 87	30, 83
Loweſt,	6	10	7	29, 92	29, 90	29, 92
Mean ſtat.	26	28	25	30, 37	30, 36	30, 39

The weather variable---frequent ſnows and rains. Predominant winds from W. to N. E. The mercury in the barometer ranged exceeding high. On the 23d, a ſevere ſnow-ſtorm, in which the ſnow fell twenty inches deep---wind N. E. The two laſt days intenſely cold. Forty-four inches of ſnow fell during the month---the ground conſtantly covered. Fourteen days of falling weather.

Greateſt degree of heat on the 4th, at 1, P. M.---barom. at 30, 25---wind W.---fair. Greateſt deg. of cold on the 31ſt, at 8, A. M.---barom. at 30, 87---wind S. W.---fair. Barom. higheſt on the 2d, at 8, A. M.---therm. 24°---wind N.---fair: loweſt on the 25th, at 2, P. M.---therm. at 22°---wind S.S.W. ---fair.

In

In the evening of the 2d, a faint Aurora Borealis----wind S. W.---ſnowed the preceding day in the morn.---the following rainy. Another in the night of the 9th---wind N. W.---preceding day miſty---ſnowed on the four following days.

Diſeaſes in *Ipſwich* ; rheumatiſms, palſies, coughs, ophthalmias : In *Salem* ; cholics, catarrhal fevers, ophthalmias, coughs and defluctionary diſorders : In *Beverly* ; worms, peripneumonies and other pulmonic diſorders.

FEBRUARY.

	Therm.			Barom.		
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.
Higheſt,	37	40	39	30, 99	30, 93	30, 83
Loweſt,	6	15	18	29, 84	29, 62	29, 90
Mean ſtat.	27	30	30	30, 38	30, 32	30, 33

Bluſtering, ſtormy and cold----few pleaſant days----ground covered with a conſiderable depth of ſnow. Predominant winds from W. to N. E. Eight days of falling weather. Fifteen inches of ſnow fell during the month.

Greateſt deg. of heat on the 22d, at 2, P. M.----barom. at the loweſt---wind S. W.---cloudy. Greateſt deg. of cold on the 1ſt, at 8, A. M.---barom. higheſt---wind N. W.---fair.

An Aurora Borealis in the evening of the 6th---wind N.---the preceding and following days fair ; but on the third and fourth days after, it ſnowed.

Diſeaſes in *Ipſwich* ; worm caſes, pleuriſies—Very healthy : In *Salem* ; cholics, anginas, pleuriſies, rheumatiſms, ſcrophulas : In *Beverly* ; pulmonic diſeaſes, ſmall pox.

MARCH.

	Therm.			Barom.		
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.
Higheſt,	43	50	44	30, 68	30, 70	30, 60
Loweſt.	21	31	33	29, 66	29, 63	29, 43
Mean ſtat.	35	40	37	30, 09	29, 99	30, 09

The

The weather, in general, mild. Predominant winds from S. W. to N. Small quantity of ſnow with rain fell on the 11th. The ground moſtly bare by the middle of the month. The latter part of the month windy. Six rainy days, in which a large quantity of rain fell ; but no ſevere ſtorm. Grain appears to have been very little injured by the winter.

Greateſt deg. of heat on the 14th, at 1, P. M.---barom. 30, 02---wind S. W.---ſunſhine and clouds. Greateſt deg. of cold on the 4th, at 7, A. M.---barom. at 30, 58---wind N. W.---fair. Barom. higheſt on the 8th, at 2, P. M.---therm. at 38° ---wind N. E.---cloudy : loweſt on the 27th, at 9, P. M.---therm. at 42°---wind high at S. W.---cloudy.

A faint Aurora Borealis on the 9th at night---wind W.---preceding day fair---on the following, rain and ſnow. On the 14th, a bright parhelion, ſouth of the ſun, at 7, A. M. In the morning of the 18th, very ſevere thunder---two houſes, a barn and many trees ſtruck with the lightning in this town.

Diſeaſes in *Ipſwich* ; cholera morbus, pulmonary conſumptions, rheumatiſms, colds, coughs, ophthalmias, ſcrophulas : In *Salem* ; ophthalmias, ſcrophulas, bad coughs : In *Beverly* ; remitting fevers.

APRIL.

	Therm.			Barom.		
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.
Higheſt,	56	68	62	30, 53	30, 48	30, 50
Loweſt,	39	43	41	29, 65	29, 67	29, 66
Mean ſtat.	46	52	49	29, 98	30, 01	30, 05

The firſt part of the month, warm and pleaſant. Vegetation advanced with great rapidity. The wind frequently between E. and S. and between S. and W.---though it prevailed moſtly between W. and N. But from the 16th to the

end

end of the month, the wind was, for the moſt part, northerly, very high, and frequent cold ſtorms of rain. Twelve days on which rain fell. From the 19th to the 25th, wind conſtantly N. E. and more or leſs rain fell every day.

Greateſt deg. of heat on the 15th, at 2, P. M.---barom. at 29, 84---wind S.---fair. Greateſt deg. of cold on the 11th, at 6, A. M.----barom. 30, 59----wind N. N. E.----cloudy. Barom. higheſt on the 26th, at 6, A. M.----therm. 43°----wind N. N. W.---cloudy : loweſt on the 4th, at 6, A. M.---therm. 51°----wind very high at W. N. W.----clouds and ſunſhine.

The Aurora Borealis appeared in the night of the 2d,---wind W.---and of the 4th,---wind W. N. W.---the preceding and following days fair.—Wind very high on the 5th and 6th. Another Aurora in the night of the 14th,---wind W. S. W.---preceding and following days fair.

Diſeaſes in *Ipſwich* ; putrid and ſlow fevers, dyſenteries, cholics—Sickly : In *Salem* ; chin coughs, cholics, ophthalmias, pleuriſies, peripneumonies, rheumatiſms, catarrhal fevers—Very ſickly : In *Beverly* ; diſorders in the firſt paſſages, tumors.

MAY.

	Therm.			Barom.		
	A.M.	Noon.	P.M.	A. M.	Noon.	P. M.
Higheſt,	61	68	63	30, 32	30, 30	30, 28
Loweſt,	47	47	47	29, 28	29, 34	29, 60
Mean ſtat.	54	59	56	29, 91	29, 90	29, 95

The month very cool and wet---no froſt. Prevailing winds from W. to N. and N. E. Vegetation backward. Peach, and ſome other fruit-trees, injured by the winter. Fourteen days on which rain fell.

Greateſt

Greateſt deg. of heat on the 12th, at 1, P. M.---barom. 29, 65---wind N.W.---fair. Greateſt deg. of cold on the 4th---the mercury ranged at the ſame height morning, noon and night ---barom. roſe from 29, 61 to 29, 80---wind N.---clouds and rain. The night was very remarkably light, although it was cloudy and no moon; probably occaſioned by a very bright Aurora Borealis. Barom. higheſt on the 17th, at 1, P. M.---therm. 53°---wind N.E.---fair: loweſt on the 10th, at 6, A.M. ---therm. 58°---wind N. W.---fair.

An Aurora Borealis in the night of the 5th---wind N.N.W. —of the 6th---wind S. W.—of the 9th---wind S. S. W.—and of the 22d---wind S. W. Rain on the preceding and following days of the four firſt; fair weather preceding and following the laſt of them. Thunder and lightning on the 13th.

Diſeaſes in *Ipſwich*; convulſions, bilious cholics, putrid fevers, worms: In *Salem*; chin coughs, cholics, catarrhal fevers, convulſions—Sickly: In *Beverly*; pulmonic fevers, worms.

JUNE.

	Therm.			Barom.		
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.
Higheſt,	80	88	81	30, 43	30, 31	30, 39
Loweſt,	54	62	56	29, 27	29, 10	29, 23
Mean ſtat.	66	75	70	29, 79	29, 62	29, 76

Predominant winds from S. W. to N. W. Frequent mild ſhowers—very little thunder and lightning—only one whole day cloudy during the month. From the 15th to the 24th, extremely ſultry. The weather exceedingly favourable to vegetation. All kinds of corn, graſs and garden-productions, promiſe plentiful crops. Little injury done by inſects and rep-

 tiles,

tiles, except canker-worms on apple-trees; by which many orchards, for years paſt, have not only been deprived of fruit, but the trees almoſt deſtroyed.*

Greateſt deg. of heat on the 22d, at 1, P. M.---barom. 29, 10---wind W. S. W.---ſunſhine and clouds. Greateſt deg. of cold on the 8th, at 6, A. M.---barom. 30, 36---wind high at S. W.---fair. Barom. higheſt on the 9th, at 7, A. M.---therm. 50°---wind S. W.----fair: loweſt on the 23d, at 1, P. M.---therm. 71°---wind high at S. S. E.---heavy ſhower of rain.

Northern lights in the evenings of the 5th and 6th---wind W. N. W.----on the 3d and 4th, ſhowers of rain----the ſix following days fair. Diſtant lightning on the 6th----thunder and lightning on the 19th, 22d and 23d.

Diſeaſes in *Ipſwich*; ſlow fevers, worms, rheumatiſms, pleuriſies, pulmonary conſumptions: In *Salem*; chin coughs, and

* Among the many experiments that have been made for deſtroying canker-worms, tarring round the body of the trees ſeems to have been the moſt effectual: but if the tar be applied on the bark, it will injure the trees, eſpecially if they are young, nearly as much as the worms. This injury, however, may be entirely prevented, and the worms more effectually deſtroyed, by putting, next the bark, a clay morter well mixed with hair or chopped ſtraw, about an inch thick; upon the morter a ſtrip of canvaſs or birch bark: then take a large rope of ſwingled tow, twiſted by hand, and make two or three turns round the tree, below and cloſe to the canvaſs, drawing it tight upon the moiſt morter to prevent the tar from running down. Let the canvaſs be tarred every day, juſt before ſunſet, from the time the ſnow is gone under the trees, in the ſpring, until no worms are found on the tar. When the worms have done paſſing, the whole is to be removed from the trees. By this method much leſs tar is uſed; and it has been found, by repeated experiments, that the worms will be deſtroyed in two years without the leaſt injury to the trees. But compleat ſucceſs is not to be expected, unleſs the trees are tarred as ſoon as the ſnow, if it lays late in the ſpring, is melted away about their bodies, and faithfully continued, every day, until the worms have done paſſing.

and vomitings and purgings among children: In *Beverly*; chronic disorders.

JULY.

	Therm.			Barom.		
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.
Higheſt,	79	84	80	30, 05	29, 81	30, 00
Loweſt,	61	68	60	29, 21	29, 06	29, 15
Mean ſtat.	69	71	66	29, 64	29, 42	29, 57

The whole of the month, eſpecially the latter part, very dry. A few ſmall ſhowers of rain. Frequent heavy fogs, and cool nights. Winds principally from W. to N. Siberian wheat entirely deſtroyed by a blaſt or mildew---rye in general ſhared the ſame fate—oats and barley greatly injured----Indian corn, and the later garden eſculents ſuffered from the drought and cold ---plentiful crops of Engliſh hay.

Greateſt deg. of heat on the 15th, at 2, P. M.----barom. loweſt---wind S. W.---ſunſhine and clouds. Greateſt deg. of cold on the 20th, at 9, P. M.---barom. 29, 61---wind S. W. ---fair. Barom. higheſt on the 20th, at 8, A. M.----therm. 68°---wind S. W.---cloudy.

Northern light in the evening of the 9th---wind S. W.--- the preceding night rain----the following days fair and cool: alſo, in the evening of the 20th---wind S. W. --preceding days fair---the third day after, rain. Thunder and lightning on the 24th.

Diſeaſes in *Ipſwich*; diarrhæas, pleuritic fevers: In *Salem*; putrid fevers, cholics, vomiting blood, chin cough, choleras, vomiting and purging among children: In *Beverly*; worm fevers.

AUGUST.

	Therm.			Barom.		
	A.M.	Noon.	P.M.	A. M.	Noon.	P. M.
Higheſt,	79	85	76	30, 30	30, 12	30, 22
Loweſt,	55	66	61	29, 26	29, 20	29, 37
Mean ſtat.	67	73	69	29, 82	29, 65	29, 85

Very dry---ſmall ſhowers of rain on the 3d, 10th, 13th, 19th and 26th. Foggy nights and mornings from the 18th to the 27th. Winds very variable---prevailed moſtly from W. to N. Indian corn and garden vegetables ſuffered by the drought. Paſtures exceedingly dried up. Salt graſs very good.

Greateſt deg. of heat on the 9th, at 2, P. M.----barom. loweſt---wind S. W.---fair. Greateſt deg. of cold on the 13th, at 7, A. M.---barom. higheſt---wind W.---fair.

Faint northern lights in the evenings of the 26th and 28th, ---wind N. W.----fair and cool after them. On the 9th, a few claps of thunder, with lightning.

Diſeaſes in *Ipſwich* ; dyſenteries, ſlow fevers, worm caſes : In *Salem* ; cholera morbus, chin coughs, mild dyſenteries, vomiting and purging among children : In *Beverly* ; cholera morbus.

SEPTEMBER.

	Therm.			Barom.			
	A. M.	Noon.	P.M.	A. M.	Noon.	P. M.	Rain. Inch.
Higheſt,	74	86	78	30, 40	30, 22	30, 25	
Loweſt.	47	56	51	29, 51	28, 97	29, 56	
Mean ſtat.	59	67	59	30, 02	29, 80	29, 95	0,703

Winds variable, and frequently very high---prevailed moſtly between S. and N. W. The drought extremely ſevere---only four very ſmall ſhowers during the month. The dews were commonly large, and preſerved the verdure of ſome kinds of vegetables. In the latter part of the month, the atmoſphere

conſtantly

conſtantly loaded with a ſmoky vapour. The ground, in many places, ſaid to be dried to a mere duſt, as low as four or five feet from the ſurface. The withered ſtate of many large groves of trees, exhibit a melancholy evidence of the extreme dryneſs of the ground. Fields of Indian corn as white as they uſually are the laſt of October, with their ears hanging down, and huſks ſeparated. All kinds of garden eſculents greatly ſuffered, and many of them periſhed. Horſes and cattle fed at barns before the middle of the month.

Greateſt deg. of heat on the 5th, at 3, P.M.---barom. loweſt ----wind extremely high at S. W. The mercury fell three-fourths of an inch from 7 in the morning to 3 in the afternoon, and, as the wind abated, roſe as much in about ſix hours. Greateſt deg. of cold on the 27th, at 7, A. M.---barom. 30, 10---wind W. N. W.---fair. Barom. higheſt on the 14th, at 6, A. M.---therm. 54°---wind W.---ſmoky air.

Frequent northern lights, viz. in the evening of the 5th, ſmall---wind W.—the 6th ; wind E.---rain the next day :—the 12th, very bright ; wind W.----cool the next day :—the 13th ; wind N. N. W.---rain the next day :—the 15th ; wind N. W.---fair after it :—the 22d ; wind S. W.---fair after it :—the 30th ; wind N. W.---ſprinkling of rain next day.

Diſeaſes in *Ipſwich* ; continued fevers, worms : In *Salem* ; cholera morbus, chin coughs, mild dyſenteries, vomiting and purging among children : In *Beverly* ; ſlow fevers, cholera morbus.

OCTOBER.

	Therm.			Barom.			
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.	Rain.
Higheſt,	59	64	62	30, 52	30, 51	30, 50	Inch.
Loweſt,	42	45	44	29, 62	29, 59	29, 6[illegible]	
Mean ſtat.	49	53	51	30, 08	29, 97	30, [illegible]	3,133

Frequent mild rains. Predominant winds from S. W. to N. W. In the night of the 5th, water froze abroad. On the 17th and 18th, wind exceſſive high, with rain and hail. Fifteen days on which rain fell.

Greateſt deg. of heat on the 3d, at 1, P. M.---barom. 29, 75---wind W.---fair. Greateſt deg. of cold on the 5th, at 7, A. M.----wind E. N. E.----cloudy. Barom. higheſt on the 28th, at 7, A. M.---therm. 43°---wind N. W.---fair: loweſt on the 6th, at 1, P. M.---therm. 63°---wind N. W.---fair.

Frequent northern lights in the firſt part of the month---wind between S. W. and N. W.---rain within two or three days after each of them.

Diſeaſes in *Ipſwich*; chin coughs, continued and putrid fevers, worms: In *Salem*; dyſenteries, rheumatiſms, ſlow fevers, mumps: In *Beverly*; ſlow fevers.

NOVEMBER.

	Therm.			Barom.			
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.	Rain.
Higheſt,	51	55	54	30,88	30, 85	30,76	Inch.
Loweſt,	22	24	27	29,51	29, 55	29,50	
Mean ſtat.	37	41	41	30, 15	30, 12	30,09	4,533

Predominant winds from S. W. to N. W. Frequently cloudy. A ſtorm of ſnow on the 21ſt---wind N.---ſnow fell four and an half inches deep. The ground very little froze, and the ſnow melted in a few days. Nine days of falling weather.

Greateſt deg. of heat on the 7th, at 2, P.M.---therm. loweſt----wind S. W.----cloudy. Greateſt deg. of cold on the 29th, at 8, A.M.---barom. 30,60---wind W.---fair. Barom. higheſt on the 10th, at 8, A. M.---therm. 33°---wind N.---fair.

The

The Aurora Borealis appeared only in the evening of the 26th---wind W. N. W.---cold and windy after it.

Diseases in *Ipswich*; rheumatisms, cholics: In *Salem*; slow fevers, rheumatisms, erysipelas, mumps, cholics: In *Beverly*; hæmoptoes, worms.

DECEMBER.

	Therm.			Barom.			
	A.M.	Noon.	P.M.	A. M.	Noon.	P. M.	
Highest,	50	53	50	30,75	30,71	30,83	Rain.
Lowest,	17	21	14	29,37	29,50	29,56	Inch.
Mean stat.	35	37	34	30,15	30,09	30,15	3,601

The weather, in general, pleasant; the air, on many days, as pleasant as in April or May. Prevailing winds from S. W. to N. W. The ground bare and very little froze. Snow fell three inches deep on the 30th and 31st. Seven days of falling weather.

Greatest deg. of heat on the 4th, at 2, P. M.---barom. 29, 92---wind S. W.---fair. Greatest deg. of cold on the 15th, at 10, P. M.----barom. 30,73----wind N. N. W.----fair. Barom. highest on the 8th, at 10, P. M.----therm. 37°----wind W. N. W.---fair: lowest on the 31st, at 10, P. M.---therm. 37°---wind N. W.---snowed.

Diseases in *Ipswich*; pulmonary consumptions, hæmoptoes—Very healthy: In *Salem*; slow fevers, pleurisies, rheumatisms, bad coughs, putrid sore throats: In *Beverly*; cholics, tooth-ach, coughs, &c.

Thermometer.

1782.	Thermometer. Greateſt Height.	Leaſt Height.	Mean Height.	Barometer. Greateſt Height.	Leaſt Height.	Mean Height.	Rain. Inches.
January,	45	6	26	30, 88	29, 90	30, 37	
February,	40	6	29	30, 99	29, 62	30, 34	
March,	50	21	37	30, 70	29, 43	30, 06	
April,	68	39	49	30, 53	29, 65	30, 01	
May,	68	47	56	30, 32	29, 28	29, 92	
June,	88	54	70	30, 43	29, 10	29, 72	
July,	84	60	69	30, 05	29, 06	29, 54	
Auguſt,	85	55	70	30, 30	29, 20	29, 77	
September,	86	47	62	30, 40	28, 97	29, 92	0,703
October,	64	42	51	30, 52	29, 59	30, 04	3,133
November,	55	22	40	30, 88	29, 50	30, 12	4,533
December,	53	17	35	30, 83	29, 37	30, 13	3,601
Whole Year,	88	6	50	30, 99	28, 97	29, 99	11,970 Since Aug.

1783.

JANUARY.

	Therm. A.M.	Noon.	P.M.	Barom. A.M.	Noon.	P.M.	
Higheſt,	42	46	45	30, 90	30, 86	30, 82	Rain.
Loweſt,	7	12	14	29, 48	29, 41	29, 42	Inch.
Mean ſtat.	28	32	32	30, 10	30, 05	30, 06	4,033

The ſtate of the atmoſphere variable, and our feelings very diſagreeably affected by the conſtant viciſſitudes of a mild and extreme cold air. The wind frequently between N. and N.E. and between S. W. and W. but prevailed moſtly between W. and N. W. On the 8th, at 9, P. M. the therm. abroad, 5° below c, and, at 8 the next morning, 10° below 0. The ground covered with ſnow from the 5th to the end of the month. A ſevere ſnow-ſtorm on the 10th, with N. E. wind. Eleven days of falling weather. Snow fell twenty-three inches in the month.

Greateſt deg. of heat on the 25th, at 1, P. M.---barom. 29, 68----wind W. S. W.----fair. Greateſt deg. of cold on the 9th,

9th, at 8, A. M.---barom. higheſt----wind W. N. W.---fair. Barom. loweſt on the 19th, at 1, P. M.---therm. 44°---wind S. W.---fair.

An Aurora Borealis in the night of the 26th---wind N. W. preceding days fair---the four following, cold, with ſprinklings of ſnow.

Diſeaſes in *Ipſwich*; pleuritic fevers, anginas, coughs, tooth-achs: In *Salem*; bad coughs, anginas, tooth-achs, rheumatiſms, pleuritic fevers: In *Beverly*; remitting fevers, and nervous.

FEBRUARY.

	Therm.			Barom.			
	A.M.	Noon.	P.M.	A. M.	Noon.	P. M.	
Higheſt,	51	53	52	30, 84	30, 61	30, 83	Rain.
Loweſt,	1	12	10	29, 76	29, 64	29, 73	Inch.
Mean ſtat.	34	37	37	30, 28	30, 19	30, 26	4,907.

The weather more capricious than the laſt month. The varieties of cold, warm, fair, cloudy, rainy, ſnowy and foggy weather were experienced every few days through the month. On the 3d, at 8, A. M. the therm. out doors, ſtood at 8° below 0. Farmers plowed on the 21ſt. Winds variable, but moſt prevalent from S. W. to W. Ground covered with ſnow until the 18th. A very denſe ſmoke-like fog in the evening of the 10th, attended with a ſingular kind of ſcent, ſomewhat reſembling that of burned leaves. Thirteen days of cloudy and falling weather. Ten inches of ſnow fell during the month.

Greateſt deg. of heat on the 19th, at 2, P. M.----barom. loweſt---wind S. S. W.---miſty. Greateſt deg. of cold on the 3d, at 7, A. M.---barom. 30,37----wind W. N. W.----fair. Barom. higheſt on the 9th, at 7, A. M.---therm. 27°---wind N. E.---cloudy.

A faint Aurora Borealis in the evening of the 2d----wind W. N. W.—and of the 27th---wind W.---fair for ſeveral days after them.

Diſeaſes in *Ipſwich* ; coughs, bilious cholics, rheumatiſms —Healthy : In *Salem* ; mild, continued and rheumatic fevers, bad coughs : In *Beverly* ; inflammations of the eyes, tumors.

MARCH.

	Therm.			Barom.			
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.	Rain. Inch.
Higheſt,	50	56	55	30, 73	30, 41	30, 53	
Loweſt,	16	24	21	29, 30	29, 30	29, 28	
Mean ſtat.	33	43	40	30, 12	30, 02	30, 05	1,733

Several ſmall ſnows, which ſoon melted ; the air mild. Predominant winds from S. S. W. to N. W. The ground bare the greater part of the month, and very little froze. Six days of falling weather.

Greateſt deg. of heat on the 29th, at 1, P. M.---barom. 29, 72---wind S. E.---miſty. Greateſt deg. of cold on the 11th, at 7, A. M.----barom. 30, 50----wind W. N. W.----fair. Barom. higheſt on the 13th, at 7, A. M.---therm. 25°---wind N. N. W.---fair : loweſt on the 8th, at 11, P. M.---therm. 43°---wind very high at N.N.W.---fair.

A ſmall Aurora Borealis in the evenings of the 2d and 26th ---wind W.N.W.—the following days fair. In the evening of the 29th, the heavens were illuminated with a very bright and ſingular northern light. At 8h. 4′, when I firſt ſaw it, the northern heavens, as far as E. N. E. and W. S. W. were interſperſed with numerous Auroral clouds, and very bright ſpots, ſomewhat reſembling lighted torches. From the luminous ſpots converging corruſcations ſhot up, with a quick and tremulous motion, towards the zenith. The luminous clouds were

were continually changing their form and ſituation, moving with a waving or flaſhing motion. At the ſame time, there was a bright glade or zone of light, compoſed of very fine ſtriæ, S. of the zenith; which extended acroſs the hemiſphere, in the S. E. and S. W. points, within 25° of the horizon. The ſouthern limb of the zone extended almoſt as far as the cloudy ſtar in *Cancer*, which was nearly on the meridian. At $8^{h.}$ 15′, the ſtriæ in the zone, and ſtriated corruſcations from every other direction, approached towards a common center in the neck of *Leo major*, and formed a kind of vortex, which ſoon became two ſegments of a circle, and then changed into detached, flaſhing clouds. At 50′ after $8^{h.}$, a very extenſive and denſe Auroral cloud was formed in the W. and N. W. with numerous ſtriæ curiouſly turned around its heads and indentations. At half after $9^{h.}$, corruſcations from the N. extended beyond the zenith. At $10^{h.}$, the light appeared only in the N. and greatly diminiſhed. There appeared to be an extremely rare fluid almoſt continually flaſhing beneath the ſtriated vapour, in various directions. The wind at W. and very ſmall till $10^{h.}$, when it breezed up freſh at N. W. At $10^{h.}$, therm. 53°, barom. 29, 72. Five preceding and ſeven following days fair.* Faint

 northern

* By a letter from the Reverend Dr. *Stiles*, Preſident of *Yale-College*, which I received ſoon after, it appears, that the extent of this northern light near the zenith, and the meeting of the corruſcations, were obſerved at *New-Haven*, (computed diſtance 180 miles, S. W.) to be as far S. and nearly in the ſame points in the heavens, as they were here. He ſays, that "At 8^{h} 10′, the Auroral corruſcations " from the eaſtern, weſtern and northern heavens, concurred in a center 12° S. of " the zenith, in a line from the two ſtars (*Caſtor* and *Polux*) in the head of *Gemini* " to *Cor Leonis*. Had it been at the ſummit of the atmoſphere, it muſt have ap" peared 45° or 50° S. of the zenith, at the diſtance of fifty miles N. of *New-Haven*; " and yet the Reverend Mr. *Atwater*, of *Weſtford*, fifty miles N. obſerved it at 8^{h} " 10′, very nearly in the ſame place, and not S. of *Cor Leonis*.

northern lights in ſeveral of the preceding and following nights. Two bright parhelia on the 8th, in the morning.

Diſeaſes in *Ipſwich* ; coughs, pulmonic complaints—Healthy : In *Salem* ; inflammatory, pleuritic and rheumatic fevers, abſceſſes ; In *Beverly* ; pulmonic fevers, rheumatiſms, worms, &c.

APRIL.

	Therm.			Barom.			
	A.M.	Noon.	P.M.	A. M.	Noon.	P. M.	
Higheſt,	60	80	71	30, 70	30, 52	30, 57	Rain.
Loweſt,	38	40	40	29, 30	29, 32	29, 20	Inch.
Mean ſtat.	47	54	50	30, 10	30, 00	30, 07	1,007

The weather warm and pleaſant. Winds principally from S. to W. N. W. The air frequently ſmoky. The 17th, exceſſive warm for this month ; the therm. ranged at 82°, within doors, at 5, P. M. The ground very dry, which ſeems to have retarded vegetation. Five days on which rain fell.

Greateſt deg. of heat on the 17th, at 2, P. M.---barom. 29, 49---wind S.W.---fair. Greateſt deg. of cold on the 13th, at 7, A. M.---barom. 30,44---wind N. N. W.---fair. Barom. higheſt on the 24th, at 6, A. M.---therm. 48°---wind N.---cloudy : loweſt on the 12th, at 11, P. M.----therm. 42°----wind N. W.---rainy.

Early in the evening of the 7th, there appeared a bright Aurora Borealis, forming an arc about 20° above the horizon in the N. At 20′ after $8^{h.}$, the brightneſs greatly increaſed ; and lucid ſpots, reſembling torches, at different heights above the arc, emitted numerous corruſcations. At $8^{h.}$ 46′, a very bright Auroral zone was formed from E. to W. N. W. paſſing the meridian near the zenith. Its motion was viſible and uniform towards the S. preſerving its poſition as to the E. and W. points.

points. It appeared to be a luminous vapour of considerable density, somewhat broken near the meridian; but the edges were so well defined that its breadth was easily measured with a sextant. The mean of the breadth, taken at several times and in different parts, was 16° 10′. In its progress, it passed above several small clouds, which appeared very black, accurately defined, and far below the luminous vapour. After passing a little S. of *Procyon*, which it entirely obscured, it became stationary at 36° 20′ S. of the zenith. In a few minutes the light grew faint, and, at $9^{h.}$ 2′, wholly disappeared. Soon after, another similar zone formed N. of the zenith, but much fainter, and not so broad as the former. It passed 5° 40′ S. of the zenith, and disappeared. Before $9^{h.}$ the light in the N. was greatly diminished, and appeared like a common Aurora. The wind was N. W. and very small. At $9^{h.}$, therm. 49°----barom. 30,19. The preceding day, cloudy and rain---the third day after, rain and hail. There were also faint Auroras in the evenings of the 12th, 26th and 27th---the wind N. W.—rain on the day preceding that of the 12th, and rain, with thunder and lightning, that of the 26th—the succeeding days fair and cool.

Diseases in *Ipswich*; pleuritic fevers, worms, cholics, ophthalmias: In *Salem*; inflammatory and slow fevers, cholics, bad coughs: In *Beverly*; rheumatisms, coughs,

MAY.

	Therm.			Barom.			
	A.M.	Noon.	P.M.	A.M.	Noon.	P.M.	Rain.
Highest,	67	78	69	30, 59	30, 32	30, 42	Inch.
Lowest,	45	50	49	29, 42	29, 33	29, 42	
Mean stat.	51	61	57	30, 02	29, 88	29, 96	4,005

Plentiful

Plentiful rain on the 8th, 9th and 10th, but the air very cool after it, especially in the night, which greatly retarded vegetation. Winds most prevalent from S. S. W. to W. N. W. Seed sewed last month lay long in the ground, and much of it perished. Eight days on which rain fell.

Greatest deg. of heat on the 18th, at 1, P. M.----barom. lowest---wind S.---fair. Greatest deg. of cold on the 5th, at 7, A. M.----barom. 29,79----wind N. W.----fair. Barom. highest on the 28th, at 6, A. M.---therm. 53°---wind N.W. ---fair.

Faint Aurora Borealis in the evenings of the 2d and 13th---wind N. W.---clouds and rain succeeded them. Severe thunder and lightning on the 23d, at 5, P. M.

Diseases in *Ipswich* ; slow fevers, coughs, measles : In *Salem* ; measles epidemic, inflammatory fevers, rheumatisms : In *Beverly* ; anginas, tonsilaris, tumors.

JUNE.

	Therm.			Barom.			
	A.M.	Noon.	P.M.	A. M.	Noon.	P. M.	Rain.
Highest,	76	86	85	30,42	30,41	30,41	Inch.
Lowest,	53	57	54	29,45	29,10	29,38	
Mean stat,	66	75	69	29,78	29,58	29,73	3,438

The temperature of the atmosphere, this month, exceedingly warm and moist, which produced a most rapid vegetation. Winds most prevalent from S. to W. Apple-trees less injured by canker-worms than the last year. Twelve rainy days.

Greatest deg. of heat on the 19th, at 2, P. M.---barom. 29,17---wind S. W.---fair. Greatest deg. of cold on the 1st, at 6, A. M.---barom. highest---wind N.E.---cloudy. Barom. lowest on the 8th, at 2, P. M.---therm. 75°---wind very high at S. W.---fair.

Very

Very faint Aurora Borealis in the evenings of the 13th and 29th---wind W.---ſhowers on the following days. Frequent thunder and lightning.

Diſeaſes in *Ipſwich*; ſlow fevers, meaſles, eryſipelas, worms, pulmonary conſumptions: In *Salem*; meaſles, diſorders of the firſt paſſages, ſynochi, peripneumonies: In *Beverly*; meaſles epidemic.

JULY.

	Therm.			Barom.			
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.	
Higheſt,	81	89	85	30, 15	30, 07	30, 12	Rain.
Loweſt,	60	64	62	29, 27	28, 96	29, 26	Inch.
Mean ſtat.	68	73	65	29, 74	29, 58	29, 70	9,062

The weather very hot, with frequent heavy ſhowers of rain. Vegetation very luxuriant. Graſs, however, ſuffered ſo much by the drought and cold in the ſpring, that the crop of hay was indifferent. Grain of all kinds appeared very fine, but is greatly injured by mildew. Flax and garden eſculents exceeding good. Indian corn in a moſt flouriſhing ſtate. Garden and wild fruit, plenty. Predominant winds from S. W. to N. W. Twelve rainy days. Frequent thunder and lightning.

Greateſt deg. of heat on the 25th, at 2, P. M.----barom. loweſt---wind S. W.---ſhower approaching. Greateſt deg. of cold on the 1ſt, at 6, A.M.---barom. 29,78---wind N. E.--- cloudy. Barom. higheſt on the 29th, at 6, A. M.----therm. 63°---wind N. W.---fair.

Diſeaſes in *Ipſwich*; meaſles, diarrhæas, ſlow fevers, pulmonic complaints: In *Salem*; dyſenteries, diarrhæas, ophthalmias, inflammatory fevers: In *Beverly*; meaſles epidemic.

AUGUST.

AUGUST.

	Therm. A.M.	Therm. Noon.	Therm. P.M.	Barom. A.M.	Barom. Noon.	Barom. P.M.	Rain. Inch.
Higheſt,	78	88	85	30, 20	30, 22	30, 25	
Loweſt,	55	61	59	29, 38	29, 08	29, 07	
Mean ſtat.	66	72	68	29, 80	29, 37	29, 75	4,438

The air, by turns, very warm and very cool, for this ſeaſon. On the morning of the 10th, conſiderable froſt in low ground. At the eaſtward, it is ſaid to have been ſo ſevere as to deſtroy moſt of the fields of Indian corn. On the 24th, the therm. in the ſhade abroad, ranged at 95°, at 2, P.M. Repeated large ſhowers of rain. Prevailing winds between S. W. and N. W. Eleven days on which it rained.

Greateſt deg. of heat on the 24th, at 1, P. M.----barom. loweſt---wind S. S. W.---fair. Greateſt deg. of cold on the 10th, at 6, A. M.---barom. 30, 20----wind N. W.----fair. Barom. higheſt on the 26th, at 10, P. M.----therm. 61°----wind N. E.---cloudy.

Small Aurora Borealis in the evening of the 16th---wind W.—and of the 19th---wind N. W. Rain and thunder the ſecond day after the firſt---fair ſeveral days after the laſt. Thunder and lightning on the 3d, 8th, 13th and 18th.

Diſeaſes in *Ipſwich* ; pulmonic and aſthmatic diſorders, worms—Very healthy : In *Salem* ; ſlow and rheumatic fevers, ſynochi, diarrhæas, dyſenteries, cholera morbus, cholics, vomiting and purging among children : In *Beverly* ; meaſles, diarrhæas, worms.

SEPTEMBER.

	Therm. A.M.	Therm. Noon.	Therm. P.M.	Barom. A.M.	Barom. Noon.	Barom. P.M.	Rain. Inch.
Higheſt,	69	70	64	30, 38	30, 36	30, 40	
Loweſt.	45	49	49	29, 60	29, 30	29, 47	
Mean ſtat.	57	62	57	29, 95	29, 80	29, 91	1,448

The

The weather variable. Predominant winds from S. W. to N. Froſt on the 4th and 23d, but only very tender plants injured. Garden eſculents in great plenty and perfection. Ten days on which rain fell.

Greateſt deg. of heat on the 14th, at 1, P. M.---barom. loweſt---wind S.W.---fair. Greateſt deg. of cold on the 23d at 7, A. M.---barom. 30, 38---wind N. W.---fair. Barom. higheſt on the 26th, at 9, P.M.---therm. 52°---windN.---fair.

Diſeaſes in *Ipſwich* ; worm caſes—Very healthy : In *Salem* ; ſynochi and ſlow fevers, abſceſſes, cynanche maligna, vomiting and purging among children : In *Beverly* ; meaſles, anginas, abſceſſes.

OCTOBER.

	Therm.			Barom.			
	A. M.	Noon.	P. M.	A. M.	Noon.	P. M.	
Higheſt,	55	61	67	30, 61	30, 52	30, 60	Rain.
Loweſt,	40	43	42	29, 39	29, 15	29, 38	Inch.
Mean ſtat.	49	53	51	30, 02	29, 91	29, 96	11, 607

High winds and heavy rains. A very ſevere ſtorm of rain on the 9th, and on the 18th and 19th, attended with exceſſive high winds at N. E. Towards the cloſe of the ſtorm on the 19th, conſiderable quantity of ſnow fell, but ſoon melted. In the morning of the 11th, heavy thunder, with hail and rain : alſo, ſevere thunder and lightning, with hail and rain, in the evening of the 31ſt----ſeveral buildings ſtruck, and creatures killed. Predominant winds from N. W. to N. E. Large crops of Indian corn. Apples, and other fall fruit, in greater plenty than the laſt year. No ſevere froſts. Graſs, and many kinds of vegetables retained their verdure through the month. Rained on fourteen days.

Greateſt deg. of heat on the 23d, at 1, P.M.---barom. loweſt ----wind S.S.W.---rainy. Greateſt deg. of cold on the 26th, at 7, A. M.---barom. higheſt---wind W. S. W.---fair.

 Diſeaſes

Diſeaſes in *Ipſwich*; continued fevers, worm caſes very rife: In *Salem*; ſlow and ſcarlet fevers, ſynochi, pleuriſies—Sickly: In *Beverly*; bilious remitting fevers.

NOVEMBER.

	Therm. A.M.	Therm. Noon.	Therm. P.M.	Barom. A. M.	Barom. Noon.	Barom. P. M.	
Higheſt,	49	53	52	30, 80	30, 80	30, 84	Rain.
Loweſt,	25	28	26	29, 16	29, 23	29, 37	Inch.
Mean ſtat.	36	40	39	30, 07	30, 07	30, 08	5,666

Very cold, bluſtering and ſtormy. Winds frequently very high, and moſt prevalent between W. and N. Ground froze hard on the 11th---ſnow fell on the 12th, and did not wholly go off during the month. Snowed, likewiſe, on the 28th and 29th---about four inches fell in the month. Nine days of falling weather.

Greateſt deg. of heat on the 4th, at 1, P. M.---barom. 30, 03----wind W. S. W.----fair. Greateſt deg. of cold on the 23d, at 8, A. M.---barom. 30, 56---wind W. N. W.---fair. Barom. higheſt on the 18th, at 11, P. M.---therm. 32°---wind W.---fair: loweſt on the 28th, at 8, A. M.---therm. 38°---wind N. E.---ſnowed.

A ſmall ſhock of an earthquake about 11 o'clock in the night of the 29th, but was felt by very few people in this town.

Diſeaſes in *Ipſwich*; continued fevers, worm caſes, coughs: In *Salem*; low, depreſſed fevers, cynanche maligna: In *Beverly*; bilious remitting fevers.

DECEMBER.

	Therm. A. M.	Therm. Noon.	Therm. P. M.	Barom. A. M.	Barom. Noon.	Barom. P. M.	
Higheſt,	55	54	54	30, 72	30, 58	30, 63	Rain.
Loweſt,	14	16	17	29, 18	29, 09	29, 30	Inch.
Mean ſtat.	34	37	36	30, 10	30, 03	30, 07	4,933

The

The former part of the month rather mild and pleaſant, but the latter, bluſtering, ſtormy and cold. The ground moſtly bare to the 18th, and then covered with ſnow to the end of the month. Predominant winds from W.N.W. to N.E. Seventeen days of falling weather. Snow fell fourteen inches deep during the month.

Greateſt deg. of heat on the 12th, at 8, A. M.---barom. 29,84---wind S.W.---fair. Greateſt deg. of cold on the 24th, at 8, A.M.---barom. 30,35---wind W.N.W.---fair. Barom. higheſt on the 15th, at 8, A.M.---therm. 30°---wind N.N.W. ---fair : loweſt on the 1ſt, at 1, P. M.---therm. 41°---wind N. E.---rainy.

Diſeaſes in *Ipſwich* ; putrid fevers, coughs, worm caſes— Healthy : In *Salem* ; febrile diſorders frequent, as pleuriſies, rheumatiſms, catarrhal fevers, cynanche maligna, abſceſſes : In *Beverly* ; hæmoptoes, ſlow fevers, coughs.

1783.	Thermometer.			Barometer.			Rain.
	Greateſt Height.	Leaſt Height.	Mean Height.	Greateſt Height.	Leaſt Height.	Mean Height.	Inches.
January,	46	7	31	30, 90	29, 41	30, 07	4,033
February,	53	1	36	30, 84	29, 64	30, 24	4,907
March,	56	16	39	30, 73	29, 28	30, 06	1,733
April,	80	38	50	30, 70	29, 20	30, 06	1,007
May,	78	45	56	30, 59	29, 33	29, 95	4,005
June,	86	53	70	30, 42	29, 10	29, 79	3,438
July,	89	60	69	30, 15	28, 96	29, 67	9,06[illegible]
Auguſt,	88	55	69	30, 25	29, 07	29, 64	4,438
September,	70	45	59	30, 40	29, 30	29, 89	1,448
October,	67	40	51	30, 61	29, 15	29, 96	11,607
November,	53	25	38	30, 84	29, 16	30, 07	5,666
December,	55	14	36	30, 72	29, 09	30, 07	4,933
Whole Year,	89	1	50	30, 90	28, 96	29, 95	56,277

XVI. *An Account of ſeveral Strata of Earth and Shells on the Banks of* York-River, *in* Virginia; *of a ſubterraneous Paſſage, and the ſudden Deſcent of a very large Current of Water from a Mountain, near* Carliſle; *of a remarkably large Spring near* Reading, *in* Pennſylvania; *and alſo of ſeveral remarkable Springs in the States of* Pennſylvania *and* Virginia. *In a Letter from the Hon.* BENJAMIN LINCOLN, *Eſq; F. A. A. to the Rev.* JOSEPH WILLARD, *V. Preſ. A. A. and Preſident of the Univerſity at* Cambridge.

THAT this earth, ſince its formation, has met with great changes, and that the ſhores, now covered with the talleſt cedars and moſt luxuriant plants, were once waſhed by the ocean, none can deny. The land between *James-river* and *York-river*, in *Virginia*, is very level; its ſurface being about forty feet above high-water mark. It appears to have arrived to its preſent height at different periods, far diſtant each from the other, by means of the ocean: for, near *York-town*, where the banks are perpendicular, you firſt ſee a ſtratum of earth, about five feet high, intermixed with ſmall ſhells, which has the appearance of a mixture of clay and ſand. On that lies, horizontally, a ſtratum of white ſhells, the cockle, the clam, and others, an inch or two thick; then a body of earth, ſimilar to that firſt mentioned, eighteen inches thick: and on that lies another thin body of ſmall ſhells, then a third body of earth, about the ſame thickneſs as the laſt; and on that lies another body of white ſhells, of various kinds, about three feet thick, with very little ſand, or earth, mixed with them. On theſe lies a body of oyſter-ſhells, about ſix feet thick; then a body of earth to the ſurface. The oyſter-ſhells are ſo united by a very

ſtrong

ſtrong cement, that they fall only when undermined, and then in large bodies, from one to twenty tons weight. They have the appearance of large rocks on the ſhores, and are waſted by the frequent waſhing of the ſea. All theſe different ſtrata ſeem to be perfectly horizontal.

After riding about ſeven miles from *York-town*, near the center between the two rivers, I diſcovered, at a place from which a large body of earth had been removed to a mill-dam, nearly the ſame appearance as in the bank firſt mentioned.

What they call their ſtone, with which they build in *York-town*, is nothing more than ſhells, united by a ſtrong cement, which ſeems to be petrified in a degree, but is apparently affected by the weather.

ON the 2d of Auguſt, being at *Carliſle*, in the ſtate of *Pennſylvania*, I went to view a ſubterraneous paſſage, which had its entrance near a river into a rock. I followed it about two hundred and fifty feet: to this diſtance it was, in general, from ſix to ſeven feet high, and about the ſame in width. At the end of two hundred and fifty feet it divided into three branches.—As they were ſmaller, and more difficult to follow, and finding myſelf exceedingly chilled, (which coſt me one of the ſickeſt nights I ever ſuffered) I gave up the purſuit, though I had proceeded but about half the diſtance, as I was informed by Col. *Butler*, who had been near the end. It appeared to me that it was a water-courſe, as the rocks were worn ſmooth, and indented in the manner they uſually are by a long running of water over them. The appearance over head was curious; ſome parts were ſmooth like the ſides; other parts repreſented various figures, formed by the water which had penetrated through the

pores

pores of the rock, and was now petrified and petrifying on its ſurface. The bottom was apparently earth and ſmall ſtones.

About three years ſince, the people in the vicinity of this town, who lived near the mountain which is about ten miles from the village, were alarmed by a current of water overflowing the banks of the river. The cauſe they could not inveſtigate, as there had been, the night before, but a ſmall rain: however, they ſoon found the firſt effects of the water appeared within about twenty feet of the top of the mountain. Whether it burſt forth from the mountain, or was a column of water from the clouds, has not yet been aſcertained. The courſe in which it ran down the mountain was dry the next morning. It was confined to the width of twenty feet, perhaps leſs. It appeared to be about thirty feet deep, as could be diſcovered by its effects on thoſe trees which were not carried away by the water. It cut a paſſage in the ſide of the mountain, of about ſeven or eight feet wide, and near that depth. The traces of it are ſeen from the town, though, as I ſaid before, it is ten miles diſtant. One rock, of a very conſiderable weight, was thrown into the crotch of a tree, twelve feet from the ground, in which it remained for ſome time. When the water came into the valley, its impetuoſity was ſo great that it was not immediately diverted, but reached a ſmall riſing ground, through which it cut a paſſage; then followed the valley, and ſo on to the river, which was at ſome conſiderable diſtance. In its courſe, it carried off all the fences, and came upon the floors of ſome of the houſes. I have had ſome converſation with Mr. *Rittenhouſe* on the ſubject, who has been twice to ſee the effects of the water. It is his opinion, that it was not a column of water which burſted forth from the mountain, as it was near the top of one of the higheſt.

On

On my return to *Philadelphia*, in the neighbourhood of *Reading*, I came to the greateſt ſpring of water I had ever ſeen.—It is about fourteen feet deep, and about one hundred feet ſquare. A full mill-ſtream iſſues from it. The water is clear and full of fiſhes. To account for this body of water, was my enquiry. I ſoon found, that it was probably the riſing and burſting forth of a very conſiderable river, which ſunk into the ground and totally diſappeared, one mile and an half or two miles diſtant from this place.

In the northern parts of *Pennſylvania*, there is a creek, called *Oil-Creek*, which empties itſelf into the *Alleghana-river*, iſſuing from a ſpring, on the top of which floates an oil, ſimilar to what is called *Barbadoes* tar, and from which may be collected, by one man, ſeveral gallons in a day. The troops, in marching that way, halted at the ſpring, collected the oil, and bathed their joints with it. This gave them great relief, and freed them immediately from the rheumatic complaints with which many of them were affected. The troops drank freely of the waters :—they operated as a gentle purge.

There is another ſpring in the weſtern parts of *Virginia*, as extraordinary in its kind as the one juſt mentioned, called the *Burning-Spring*. It was known a long time to the hunters. They frequently encamped by it for the ſake of obtaining good water. Some of them arrived late one night, and, after making a fire, they took a brand to light them to the ſpring. On their coming to it, ſome fire dropped from the brand, and, in an inſtant the water was in a flame, and ſo continued, over which they could roaſt their meat as ſoon as by the greateſt fire. It was left in this ſituation, and continued burning for three months without intermiſſion. The fire was extinguiſhed by

excluding

excluding the air from it, or ſmothering it. The water taken from it into a veſſel will not burn. This ſhews, that the fire is occaſioned by nothing more than a vapour that aſcends from the waters.

There are two ſprings high up on the *Powtomack*; one of which has about the ſame degree of heat as blood running from the veins. It is much frequented by people who have loſt their health. The waters are drank with freedom, and alſo ſerve as a hot bath, by which much good has been experienced. The other ſpring, iſſuing from the ſame mountain, a little further up, is as remarkable for its coldneſs, as the other for its heat, and differs from common ſprings in as many degrees.

Theſe accounts I have from the beſt authority. General *Waſhington*, from whom I had my information, as well as from others, owns the land around the *Burning-Spring*, which he bought for the ſake of it.

The accounts of the other ſprings I received from a gentleman of undoubted veracity, and of great obſervation, who lately viſited them. He commanded the troops who experienced the benefit of the *Oil-Spring*. He mentioned to me another ſpring in the ſouth-weſterly part of *Virginia*, which he had not ſeen, but of which he had received a particular account from gentlemen of character. It is called the *Sweet-Spring*, from the ſweetneſs of the waters, which have been found efficacious in many diſorders, and have given relief when every other attempt has proved ineffectual.

To theſe I may add the great number of ſalt ſprings in *America*, eſpecially on the *Ohio*, and the rivers which empty into it. There is one ſpring on the *Miſſiſſippi*, from which ſalt is made ſufficient to ſupply the whole *Ilinois* country with that article.

XVII. *An Account of large Quantities of a foſſil Subſtance, containing Vitriol and Sulphur, found at* Lebanon, *in the State of* New-Hampſhire, *accompanying a Specimen. In a Letter from the Reverend* JEREMY BELKNAP, *F. A. A. and Member of the Philoſophical Society at* Philadelphia, *to* SAMUEL WILLIAMS, *L. L. D. F. A. A. and Hollis Profeſſor of Mathematics and Philoſophy in the Univerſity at* Cambridge.

Dover, September 28, 1780.

SIR,

HEREWITH I ſend you a ſpecimen of a ſtone, which, by the efflorefcence upon it, you will ſee to be rich in vitriol, and by the ſmell, you will perceive to contain a great proportion of ſulphur. It was taken out of the cellar-wall of an houſe at *Lebanon,* in the county of *York,* where it had been placed for about fifteen years. The ſame kind of ſtone is found in vaſt quantities, for a conſiderable diſtance round the ſpot. The neighbouring people uſe it for dyes, and for blacking leather, with as much ſucceſs as the beſt imported copperas. As there is plenty of wood and water there, I think a manufactory might be eſtabliſhed to great advantage. You will judge whether this hint is worth communicating to your newly eſtabliſhed Society.

I am, Sir,

Your friend and humble ſervant,

JEREMY BELKNAP.

XVIII. *An Account of yellow and red Pigment, found at* Norton, *with the Procefs for preparing the Yellow for Ufe; accompanied with Specimens. In a Letter from the Reverend* Samuel Deane, *F. A. A. to Mr.* Caleb Gannett, *Rec. Sec. A. A.*

Falmouth, May 30, 1782.

SIR,

In feveral places in *Norton*, in the county of *Briftol*, in the *Maffachufetts*, has been found a foffil, near the furface of the earth, mixed with fand and fmall pieces of iron ore, from which is extracted two kinds of fubftances ufeful in painting, viz. yellow and red.

To make the yellow, the procefs is as follows: They mount a tub, or vat, on blocks two feet high, and put into it one third part as much of the earth as will fill it: then fill it up, almoft to the brim, with water. After this, with hoes, they bruife it, and ftir it about till it is diffolved and well mixed with the water. The fand, gravel and iron ore, in about the fpace of a minute, will fink to the bottom; at which time they draw off the water, with the pigment floating in it, letting it fall through a common bread-fieve, into a vat, or tub, ftanding on the ground. When the paint is all funk to the bottom, the water is taken off through holes in the fides, and the paint dried well in the open air and funfhine, on a floor made tight and furrounded with a border, to prevent its running off. Being thoroughly dried, it is fit for grinding by the painter, making a greenifh yellow colour. And I am told, a little black paint mixed with it, renders it a beautiful olive colour.

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The yellow paint, being dried as above, and then brought to a red heat, in a kettle over a hot fire, becomes a red paint resembling *Spanish*-brown, but of a finer and brighter colour. It is used by painters instead of *Spanish*-brown. They use it for out-door work; and time will soon discover whether it will not be equally durable. The manufacturers sell it for about three pence a pound, which is cheap; and it bids fair to be of great service to the public.

In the same town is found a white fossil, out of which is made a paint resembling *Spanish*-white, or whiting. But concerning this I have not been able to gain much information.

I have left samples of the yellow and red with the Keeper of the Cabinet: and if you think fit, you may communicate this to the Academy at their next meeting.

I am, Sir,

Your most humble servant,

SAMUEL DEANE.

Mr. *Gannett.*

P. S. Since writing the above I find, that this paint has stood the weather well, in several instances, for three or four years; and bids fair to prove durable: and that the *red*, in its present state, is sold at fifteen shillings per hundred weight; which is cheaper than can be obtained from *Europe*.

XIX. *An Account of an Oil-Stone found at* Salisbury. *In a Letter from the Reverend* SAMUEL WEBSTER, *to Mr.* CALEB GANNETT, *Rec. Sec. A. A.*

Salisbury, January 24, 1783.

SIR,

I HAVE found what the goldsmiths use, and call an oil-stone, equal, if not superior, to those imported from *Turkey*.—But as it was so small as only to make two, one for each of my sons, who are goldsmiths, it is not in my power to send you a sample, It is extremely hard, and somewhat brittle ; so that I easily broke it into two pieces. When it is ground it is exceedingly smooth, and serves to smooth their engraving tools. I found it in my field by accident, and was excited, from its uncommon appearance, to take it up, not knowing, at that time, what it was. It is somewhat curdled with light and dark brown, or, when ground, it approaches to a light chocolate colour, somewhat clouded. Before it was ground some compared it to *Castile* soap. I have made considerable search for more, but without success. I doubt not, however, that we have them in the country, perhaps in plenty. I found this in moist ground. These stones are necessary for all those who make use of engraving tools, and are now very scarce and dear.

I send you a piece of marble found near the mouth of *St. John's-River*, in *Nova-Scotia*. It is found of various colours,—white, bluish and veined. I also send you a sample of salt, made from a salt-spring in the *Seneca* country, on *Mohawk-River* : and a sample of cloth, coloured black with sumach-berries alone, without copperas.

I am, &c.

SAMUEL WEBSTER.

Mr. *Caleb Gannett*.

XX. *Observations on the Culture of* Smyrna *Wheat. In a Letter from* BENJAMIN GALE, *F. A. A. Member of the Philosophical Society at* Philadelphia, *and Fellow of the Royal Society in* London, *to his Excellency* JAMES BOWDOIN, *L. L. D. Pres. A. A.*

Killingsworth, 25th August, 1783.

SIR,

I SEND you a few heads of the true *Smyrna* wheat, a species of that grain, which I apprehend is the best adapted for the horse-keeping husbandry, believing it will answer for tillage equal to our Indian corn. Dr. *Elliot* made various attempts to procure it, without succeeding. This happens to be much blasted, owing partly to the season, and in part to being late sowed, viz. late in September, after the rains came on, at the end of a long drought; and being sowed in my garden, contiguous to some barberry-bushes; to all which, *by leaving open my gate*, my sheep got in during the winter, the ground not being covered with snow, ate it off even with the ground.—But am of the opinion, from the strength of the stalk, a specimen of which I also send you, a part of the second joint, divested of the leaf which covers it, and also the upper joint which supports the ear, which is solid, it appears better able to support the heads, and will not be subject to a rupture of the vessels, which is often the case in a blasting season; and from its being about ten days earlier than common wheat, puts it still further more out of the danger of the blast. Those ears which have but one head, I apprehend, from the similarity of the leaf and stalk, are of the same species with those which have more heads: one of which has four ears of a side, springing out of the main ear,

ear, which I apprehend owing to having more room, more culture, and, perhaps, the earth, contiguous to the roots, richer. The method of culture, if you are not acquainted with *Tull's* tillage, is, to make a ſmall ridge, in form of a bed for peas, on which make two rows, at about ten inches diſtant, and the ſeeds planted at about half an inch diſtance in the rows, which muſt be hoed, and kept clean from graſs or weeds. Should you not have a curioſity yourſelf, in this way, you may perhaps oblige ſome of your friends, who may be in the farming way. It would be well to put the ſeed into the ground ſoon.

I have the honour to be, Sir, &c.

BENJAMIN GALE.

Honourable *James Bowdoin*, Eſquire.

XXI. *An Account of an Experiment for raising Indian Corn in poor Land. In a Letter from* JOSEPH GREENLEAF, *Esq; to the Reverend* JOHN CLARK, *F. A. A.*

Boston, May 26, 1785.

SIR,

WHILE I resided in the country, I found it was the opinion of the farmers, that whoever raised Indian corn paid more for it, in labour, than it was worth: that the land must be strong, highly manured, well plowed and hoed, or it would not produce a crop half equal in value to the expence bestowed upon it: that the land, in a very few years, would be worn out, and must lie useless a number of years afterwards to recover its fertility.

To convince them of their error, I purchased, of one of my neighbours, a piece of land which he affirmed was worn out, and unfit to produce any crop of any kind. The land was dry, and not a stone in it; the soil was very light and shallow, inclining to sand. The ground was over-run with briars and weeds, called *St. John's*-wort, with here and there a spire of coarse wild grass.

Upon this piece of ground I made the following experiment. In the first place I procured a plough, made under my own direction, with a sharp coulter, and a share about a fourth part of the size and weight of common plough-shares; and with a furrow-board, on a new construction, that followed the coulter edge-wise, turning the furrow over in rather a spiral form. With this plough, which required only the strength of a single horse, a furrow was ploughed through the whole length of my field,

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and, returning with the plough on the ſide next to which the furrow was turned, threw up another furrow againſt the firſt. At four feet diſtance from this another double furrow was ploughed, in the ſame manner; and ſo on, leaving a ſpace of four feet between the double furrows, through the whole field. Upon theſe double furrows potatoes were planted, leaving the ſpace of four feet between each hill. This field contained two acres and an half, and was about forty rods in length. It was ploughed and planted, in one day, with one horſe and two boys. When the potatoes came up and wanted tending, the ſame boys, with the ſame horſe and plough, turned another furrow of the unploughed ground towards the potatoes, on each ſide, and dreſſed them with their hoes: this they alſo performed in one day. At half-hilling, it was repeated, and the whole field became ploughed. At hilling, the field was croſs-ploughed, the earth thrown towards the crop each way, and dreſſed with the hoe. By this mode, two acres and an half was compleatly tilled in four days, with the labour of only two boys and one horſe; which, in the common way of managing ground, would have required ten days labour of one man, one boy, and two horſes.

The next ſpring I ploughed, between every two rows of the old potatoe-hills, two furrows, which were thrown one againſt the other, and planted my corn upon them, without any manure. The ploughing and planting was performed by the ſame horſe, plough and boys, in one day. My corn was huſbanded in the ſame manner my potatoes were the year before. A field on the other ſide of the fence, much of the deſcription and ſize of mine, was two days and an half in ploughing and planting, with one man, a boy, two horſes, and a common plough. This field,

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was planted on the ſame day with mine, and was well dunged. My corn made its appearance about two days before my neighbour's, ripened more than a fortnight earlier, and I had the largeſt crop.

I continued to plant corn in the ſame land, between the old hills as before-mentioned, for three years ſucceſſively, without carrying on any manure,—the crops increaſing about two buſhels every year. My removing to *Boſton* prevented my repeating the experiment. You will join with me in lamenting the loſs to the public of thouſands of acres of land that lie uſeleſs in this commonwealth, from a miſtaken notion that ſuch land is worn out, and not capable of producing a crop ſufficient to pay even for the ſeed that is planted.

I am, &c.

JOSEPH GREENLEAF.

The Reverend *John Clarke.*

XXII. *An Account of a singular Apple-Tree, producing Fruit of opposite Qualities; a Part of the same Apple being frequently sour, and the other sweet. In a Letter from the Reverend* PETER WHITNEY, *to the Reverend* JOSEPH WILLARD, *V. Pres. A. A. and President of the University in* Cambridge.

Northborough, July 15, 1782.

REVEREND SIR,

THERE is now growing in an orchard, lately belonging to my honoured father, the Reverend *Aaron Whitney*, of *Petershham*, deceased, an apple-tree, very singular with respect to its fruit. The apples are fair, and, when fully ripe, of a yellow colour, but, evidently, of different tastes—sour and sweet. The part which is sour is not very tart, nor the other very sweet. Two apples growing side by side, on the same limb, will be often of these different tastes, the one all sour, and the other all sweet. And, which is more remarkable, the same apple will frequently be sour on one side, end, or part, and the other sweet, and that not in any order or uniformity; nor is there any difference in the appearance of the one part from the other. And as to the quantity, some have more of the acid and less of the sweet, and so *vice versa*. Neither are the apples so different in their tastes, peculiar to any particular branches, but are found, promiscuously, on every branch of the tree. The tree stands almost in the midst of a large orchard, in a rich and strong soil, and was transplanted there about forty years ago. There is no appearance of the trunk or any of the branches having been ingrafted or inoculated. It was a number of years, after it had born fruit, before these different

ferent taſtes were noticed; but ſince they were firſt diſcovered, which is about twenty years, there has been conſtantly the ſame variety in the apples.

For the truth of what I have aſſerted, I can appeal to many perſons of diſtinction, and of nice taſtes, who have travelled a great diſtance to view the tree, and taſte the fruit; but to inveſtigate the cauſe of an effect ſo much out of the common courſe of nature, muſt, I think, be attended with difficulty. The only ſolution I can conceive is, that the *corcula*, or hearts of two ſeeds, the one from a ſour, the other from a ſweet apple, might ſo incorporate, in the ground, as to produce but one plant: or that farina, from bloſſoms of thoſe oppoſite qualities, might paſs into, and impregnate the ſame ſeed. If you ſhould think the account I have given you, of this ſingular apple-tree, will be acceptable to the *American* Academy, pleaſe to communicate it.

I am, &c.

PETER WHITNEY.

Reverend Preſident Willard.

XXIII. *A Letter from the Honourable* BENJAMIN LINCOLN, *Eſq;* F. A. A. *to the Honourable* JAMES WARREN, *Eſq;* F. A. A. *relating to the ingrafting of Fruit-Trees, and the Growth of Vegetables; incloſing the Obſervations of his Friend on the Growth of Trees downward after the firſt Year.*

Hingham, November 3, 1780.

MY DEAR SIR,

I TAKE this early opportunity, agreeable to my promiſe, to encloſe you the ſentiments of my friend on grafting, the growth of plants, trees, &c. Theſe were given on a converſation which aroſe on my mentioning, that I had obſerved, for a number of years, an apple-tree in my orchard, the natural fruit of which was early, having been grafted with a winter cyon, producing fruit very like in appearance to the fruit produced by the tree whence the cyon was taken, but deſtitute of thoſe qualities inherent in that fruit, and neceſſary to its keeping through the winter. This led me to call in queſtion the propriety of grafting winter fruit on a ſummer ſtock, and to enquire, whether the ſtock through which, I ſuppoſed, the food paſſed to the cyon, and by which it was fitted properly to nouriſh the helpleſs and newly adopted branch, would not rather aſſimulate *that*, than that the cyon could, thus fed, retain all the qualities of its parent ſtock.

I am ſenſible that there are objections to this new ſyſtem; and, perhaps, difficulties may be raiſed to it, which cannot be obviated.—But, as this may ariſe either from the erroneouſneſs of the doctrine itſelf, or from the want of knowledge in the principles of vegetation, I think it ſhould not be adopted or rejected

rejected without the fulleſt enquiry; and eſpecially, ſince a knowledge of the laws of vegetation is one of the moſt intereſting matters which can be the ſubject of diſcuſſion: for on vegetation depends our being; and in the ſame proportion as we obtain a knowledge thereof, and practiſe on that knowledge, in that proportion is our well-being promoted. That cultivation promotes vegetation, I think, none will deny: for ſurely the earth, ſpontaneouſly, gives us but a bare ſubſiſtence. The reaſons aſſigned, why the earth did not more early bear fruit, were, becauſe *there was no rain on the earth*, and becauſe *there was no man to till the ground.*—The neceſſity of which ſeems to have produced one of the firſt decrees from heaven to man, even while he was in *Eden*, ſurrounded with all the bleſſings thereof, that he ſhould dreſs the garden. Whether tilling and dreſſing the earth ſo prepares its parts that they became proper food for the plant, and thereby promote vegetation;—whether, by tilling and dreſſing, the land is fitted properly to receive the rays of the ſun, and to receive and retain a ſuitable quantity of water, with which food for the plant is ſuppoſed, by ſome, to fall;—or whether, by tilling and dreſſing, the land does really partake of more particles neceſſary to vegetation, and ſo attracts like particles floating in the air, as ſimilar bodies attract each other, and ſo light on, and feed the plant in their fall, or do reſt on the earth, are abſorbed by the roots, and thence conveyed thro' the whole plant, are queſtions which can, I think, be determined with more eaſe and greater certainty when the principles of vegetation are fully aſcertained.

Pleaſe to favour me with the reſult of your enquiries on theſe matters, and it will much oblige him who has the honour to be, &c.

B. LINCOLN.

Hon. Gen. *Warren*.

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THE idea has univerſally obtained, that *Trees grow from the root upwards*. But perhaps it may appear probable, from the following conſiderations, that *Trees, from the firſt year, grow from the top downwards*.

The growth of annual plants ſeems to be the mere expanding of the parts contained in the ſeed, or bulb, which is a more perfect and full grown ſeed, differing but little from what is commonly called ſeed. Of this, the bulb of a tulip is the beſt example, as the parts are viſible without the help of glaſſes. Upon removing the ſeveral coats of the bulb, each of which are the ſupport of a leaf, in the center of it, a large flower, near half an inch in length, will be found, and, in thickneſs, as large as a rye-ſtraw; in which the petals, ſtile, filaments and buttons are fully formed, and perfect in every reſpect but ſize and colour. The lower leaf of the plant, which, within the bulb, covers all the reſt, ſwells and expands firſt: then the next above ſwells and expands; and ſo on, until the whole are expanded: after which, the ſtalk riſes, the flower ſwells and opens, and its beautiful colours are ſeparated and exhibited to the eye. In this growth the bulb is entirely waſted, except only the fine ſkin that covered each ſquamina, which remains much thinner than white paper. In the center of the bulb, below the leaves and adhering to the ſtalk, may be ſeen a very ſmall bulb, much leſs than the ſeeds of the plant. This bulb is, however, increaſed with the growth of the leaves, until it becomes of the ſize of the parent bulb: and when the ſtalk, the leaves and fibrous roots decay and dry up, this new bulb remains, in the place of the old one, capable of a like growth the next year.

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The firſt year's growth of a tree, like that of plants, is the mere expanſion of the parts contained within the ſeed, ſo far as thoſe parts are fitted for growth ; and being expanded, the wood formed has no further growth, in any direction, but remains of the ſame ſize until it decays. Each leaf which grows on the firſt year's ſhoot, as well as thoſe of ſucceeding years, has annexed to it, immediately above its ſtem, an embryo bud, which is nouriſhed and fitted to grow the following year, and to become a branch of the future tree. The leaf having performed its maternal duty, falls to the ground, and manures the tree from whence it fell.

The wood of theſe ſaplings of a year, is uniformly of one texture ; but the wood of the next year is ſeparated from it by a circular line, which remains as long as the wood laſts. Every ſucceeding year is diſtinguiſhed in the ſame manner ; ſo that by cutting the tree on one ſide, from the circumference to the center, and counting thoſe circles, you may aſcertain its age.—— And one of the main queſtions, ariſing in the conſideration of this ſubject, is, how are theſe annual additional circles of wood formed ? Are they formed by the filling and expanding of fibres, which, too ſmall for the obſervation of our ſenſes, lie between the bark and the tree ? or are they new fibres ſhooting either from below or from above ? It appears, by examining the wounds of trees, that the wood being once ſeparated never heals up and grows together.—The new wood grows over, and covers the wound ; but the ſeparated veſſels never unite again : therefore, if the edge of a knife be paſſed tranſverſely thro' the bark half round a ſapling, and thoſe ſuppoſed extreme fine veſſels were cut off, that ſide of the tree ought to ceaſe growing, and the buds above it periſh. But the fact is otherwiſe : for, cover

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the wound ſo as the air may be prevented from carrying off the moiſture, which, when uncovered, flows from the wound, the buds above will grow nearly as well as if the wound was not made. To ſuppoſe that new veſſels, formed at the root, aſcend, and ſeeking the buds, by paſſing round the inciſion, immediately find them, is too ludicrous an objection to be ſeriouſly noticed. Let us, then, conſider the buds which are formed in the boſom of every leaf.

One of thoſe buds, rended from its parent plant, and inſerted in the bark of another tree of the ſame genius, will grow as well as if it had been continued where nature placed it, and become a compleat tree. Here, at leaſt, there is a certainty, that there are no fibres calculated to ſupport it, yet it will grow ; and the whole tree, above the inſertion in the ſtock, thus ſpringing from a foſter-bud, is exactly of the ſame nature in all reſpects, and produces the ſame fruit as the tree from which the bud was taken. This is the wonderful circumſtance, which, though often attempted, has never been clearly accounted for. We ſhall proceed to enquire, then, how buds inſerted in foreign ſtocks attain their growth.

When a bud is bro't into contact with the ſtock, and the bark of the ſtock paſſed round and upon the bark laid in with the bud, the ſap very quickly forms a gum, which glues them together, and ſtops the mouths of thoſe veſſels which had been torn by ſeparating the bark and bud from the parent tree. Whoever examines the fact, muſt be convinced, that the bud, thus laid in, never has any further adherence to the ſtock ; but remains, during the life of it, liable to be ſeparated from it by diſſolving that gum ; and, from this circumſtance, the ſize and ſhape of the wood, or bark, laid in with the bud, may be plainly diſco-

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vered many years after its insertion. Here the communication between the stock and the bud is destroyed: for, if the sap penetrated this gum, it would dissolve it, and the bud would fall off; and there can certainly no fibres be sent from the root to feed a bud, which nature had not placed there. Nothing but experiment could induce a belief, that a bud, thus situated, would grow, become a tree, blossom and bear fruit. Let us see how buds grow in the situation assigned them by nature.

The largeness of the bud, and the freedom with which it shoots, renders the peach-tree a proper subject of this enquiry. Early in the spring, when the bud first begins to swell, we shall find one or more fibres shooting from it downward. These fibres are so large, below the bud, as apparently to swell the bark, and on removing the bark the fibres may be plainly seen by the naked eye. Whoever carefully examines this fact, will scarcely doubt that this is really the manner in which buds begin to grow. Inoculations having the same power of sending out fibres from themselves as buds, in their natural situations, need no nourishment from the stock on which they are fixed; but it becomes the question, from whence is their nourishment derived?

A curious yellow carnation, presented to a gentleman at *Lancaster*, in the year 1778, being transplanted very early in the spring, and the weather proving very cold, he was obliged to take it into the house, and keep it in a room where fire was kept. Notwithstanding his utmost care in keeping the earth well watered, the plant declined, the leaves became soft, and rested on the earth, and the plant shewed every sympton of approaching death. In this state, having bended twigs over the pot, he wet a thick tow-cloth and threw over the plant, which

formed a moiſt atmoſphere round it. In a few hours the leaves became erect, and elaſtic, and within three days the whole plant aſſumed the aſpect of perfect health. The roots had a full ſupply of moiſture, but it did not grow; the leaves were ſupplied, and the plant inſtantly flouriſhed.

The firſt appearance of vegetation among trees here, is the flowing of the ſap in the ſugar maple. This begins with the froſty mornings in the month of February. Theſe hoar froſts never apppear but when the air is moiſt; and it is invariably certain that the ſap ceaſes to flow when the wind is at north-weſt and the air dry, be the ſtate of the earth as to moiſture or froſt as it may. From hence it appears, that the ſap is extracted from the air even before the leaf is expanded, and not from the earth, as is generally ſuppoſed.

The next appearance of vegetation, is the ſwelling of the bud in the ſcarlet maple; and in this, as in all other trees, it is to my purpoſe to obſerve, that the uppermoſt buds always ſwell firſt, and its beautiful bloſſoms are ſeen earlieſt to unfold on the topmoſt boughs. This cannot depend on a ſap derived from the root; for, in that caſe, the lowermoſt ſhould have unfolded firſt.

The huſbandmen of *New-Jerſey*, upon thoſe lands which do not produce oak-timber ſufficient for fencing, ſhave the bark from the pine trees in the latter part of winter, and in the ſpring, the turpentine running down over that part of the tree which has been barked, fills the pores, and preſerving it againſt the water, renders the pine a very durable poſt for fencing. The turpentine, as I conceive, being collected from the air, deſcends from the top of the tree. This practice, lately introduced, deſerves attention, not only as an argument in this queſtion, but

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as an important lesson of instruction to those who live on pine lands.

The experiments made on fruit-trees, by extending their branches into green-houses while the roots remain in the ground, need not be repeated. They are better known than understood; and can only be accounted for by supposing that their nourishment is derived from the air. Of this the following experiment may be a proof.

A branch of the maple being separated from the tree, and the lower end sealed, placed in any part of the tree, will bloom as soon as any of the adjoining branches not separated from the tree will do. The buds of trees, deriving their nourishment from the air, send down their fibres between the bark of the tree and the former year's growth of wood, and lay an additional wood over the former growth. It is upon this principle alone, that the growth of inoculations can be accounted for; and it is clear and plain, that every bud has its own pith, perfectly distinct from the tree it is attached to, and has also in itself every other part of a tree.

From a due consideration of what has been said, it will appear, that the growth of annual plants is the expanding of the parts contained within their seeds as bulbs, and a production of other seeds and bulbs, perfectly distinct and unconnected with the former; but that the growth of trees after the first year is the expanding of buds, adhering to the former growth, and the fitting of other buds for future growth attached to the tree, as well as forming of seeds, as annual plants do.

XXIV. *An Account of ſome of the vegetable Productions, naturally growing in this Part of* America, *botanically arranged. By the Rev.* MANASSEH CUTLER, *F. A. A. and M. S. and Member of the Philoſophical Society at* Philadelphia.

IN an infant country, where nature has been liberal in her productions, and internal reſources are greatly wanted, few objects can be of greater importance than natural hiſtory. Yet, unhappily, there is no branch of uſeful knowledge we have ſo little cultivated. The cultivation of this branch of ſcience will open to our view the treaſures we poſſeſs unenjoyed; and muſt eventually tend to the ſecurity and welfare of our citizens, the extenſion of their commerce, and the improvement of thoſe arts which adorn and embelliſh life.

The little progreſs we have made in exploring the foſſil kingdom, is ſufficient to convince us, that the bowels of the country are well ſtored with minerals and other uſeful foſſils; which are capable of being improved, not only for the benefit of individuals, but as national advantages.

We have, perhaps, as great a variety of indigenous plants, as any country produces, in a ſimilar climate. But a great part of them have never been ſo far noticed as to receive even a trivial name. *Canada* and the ſouthern ſtates, beſide the attention paid to their productions by ſome of their own inhabitants, have been viſited by eminent botaniſts from *Europe.* But a great part of that extenſive tract of country, which lies between them, including ſeveral degrees of latitude, and exceedingly diverſified in its ſurface and ſoil, ſeems ſtill to remain unexplored.

The almoſt total neglect of botanical enquiries, in this part of the country, may be imputed, in part, to this, *that Botany*

has

has never been taught in any of our Colleges, and to the difficulties that are ſuppoſed to attend it; but principally to the miſtaken opinion of its inutility in common life. This opinion being ſo generally prevalent, it may be neceſſary to obſerve, that, tho' all the medical properties and œconomical uſes of plants are not diſcoverable from theſe characters by which they are ſyſtematically arranged; yet the celebrated *Linnæus* has found, that the virtues of plants may be, in a conſiderable degree, and moſt ſafely, determined by their *natural* characters: for plants of the ſame *natural* claſs are in ſome meaſure ſimilar; thoſe of the ſame *natural* order have a ſtill nearer affinity; and thoſe of the ſame genus have very ſeldom been found to differ in their medical virtues. Thus, according to the ſexual ſyſtem, plants of the ſecond order in the third claſs are all eſculent, affording food for men, beaſts or birds; and no one ſpecies of all thoſe numerous genera have been found to be poiſonous. The ſtarry plants of the firſt order in the fourth claſs are chiefly diuretic. The rough-leaved plants of the fifth claſs and firſt order are mucilaginous; but thoſe of a diſagreeable taſte and ſmell, moſtly berry-bearing plants, are more or leſs corroſive and poiſonous. The umbelliferous plants, growing in dry places, are aromatic and ſtimulative, but in wet ground, often poiſonous. Plants of the ſixth claſs have roots, according to their ſmell or taſte, either eſculent or poiſonous. The plants with horned antheræ of the eighth and tenth claſſes are aſtringent, and their berries acid and eſculent. All the pulpy fruit of the twelfth claſs may be eaten with ſafety. Plants of the thirteenth claſs are chiefly poiſonous: but thoſe of the firſt order in the fourteenth are odoriferous, cephalic and reſolvent; and none of them are poiſonous. Nor is there any poiſonous plant belong-

Theſe natives were, likewiſe, poſſeſſed of the art of dyeing deep and moſt permanent black, red and yellow colours. Theſe colours were given to bone, horn, porcupine quills and other hard ſubſtances, which ſtill appear, unimpaired, on ſome of their ornaments and utenſils. The Spaniards are ſaid to have procured from the *Californian* Indians, the art of dyeing the beſt black ever yet known. The plant they employ in this dye is called the caſcalote, a ſmall ſhrub, which abounds in that country, and may probably be found within the limits of the United States.

However deſirable the knowledge of our vegetable productions may be, our progreſs muſt be ſlow, until men, verſed in this ſcience, can devote their time to the inveſtigation of them. Some advances may be made by individuals collecting the productions of their own neighbourhood, and tranſmitting accounts of them, from time to time, to the Academy. How much a correſpondence of this kind has done, in perfecting the hiſtory of the *Britiſh* plants, will appear from the numerous botanical papers publiſhed in the tranſactions of the Royal Society.

As there has never been a deſcription given of the indigenous plants in this part of the country, and it being one of the ends of the inſtitution of this Academy to promote the knowledge of natural hiſtory, I take the liberty of communicating an account of ſome of thoſe which have fallen under my obſervation. They are arranged according to the *Linnæan* ſyſtem; and the generic characters, where they were found to correſpond, are referred to *Linnæus's* deſcription in the fifth edition of his *Genera Plantarum*: The characters of the ſpecies, where there was an agreement, are taken from the tenth edition of the *Syſtema Naturæ*. A few ſynonyms from other authors are given, and

more

more might have been added, had it been conſiſtent with the limits of the paper. Some additional deſcription of moſt of them, the times of flowering and places of growth, were thought neceſſary. Thoſe plants which appear not to agree with the eſſential generic characters of any known genus, are inſerted without any generic names, but the natural characters of the fructification are particularly deſcribed. Such as appeared doubtful are diſtinguiſhed by a mark of interrogation. The *Engliſh* names are thoſe by which the plants have been called either here or in other parts of the world, except, in a few inſtances, where no trivial name was known. The medical and œconomical uſes which are mentioned, are inſerted from the beſt private information that could be obtained, or ſelected from good authorities; many of them, in particular, from a late ingenious and uſeful publication by *William Withering*, M. D. entitled, "The botanical arrangement of *Britiſh* plants."

In giving this account of indigenous plants, I have had opportunity of inveſtigating only thoſe which were found growing within the compaſs of a few miles; except a ſmall number that happened to be noticed at a greater diſtance. Many others have been obſerved, but the limits of this paper did not admit their being inſerted. The generic characters of theſe plants were minuted from freſh bloſſoms in full bloom, with the aid of a microſcope, and with as much attention as the little leiſure I have had for botanical enquiries would admit. But not having examined any of them, for any other purpoſe than mere amuſement, until the laſt ſummer, I doubt not errors will be found in this arrangement, which more time and further examination might have prevented. This I hope will be admitted as ſome apology, by every experienced botaniſt, who

knows how much time is neceſſary for inveſtigating and arranging a conſiderable number of plants in a part of the country never before explored.

Ipſwich, January 26, 1784.

MONANDRIA.

MONOGYNIA.

SALICORNIA. Linn. Gen. Plant. 10.

Salicornia articulis apice compreſſis emarginatis bifidis. Syſt. Nat. *Kali geniculatum annuum.* Park.

GLASSWORT. Saltwort. Marſh Samphire. The ſtem grows about eight or ten inches high: the main ſtem divides itſelf into numerous branches. It is found on the ſea-ſhore. Bloſſoms in September.

In *Europe* a foſſil alkali is obtained from the aſhes of this plant, which is in great requeſt for making glaſs and ſoap. It is ſaid to make a pickle little inferior to ſamphire.

DIGYNIA.

BLITUM. Linn. Gen. Plant. 14.

Blitum capitellis ſpicatis terminalibus. Syſt. Nat. *Chenopodiomorus.* Boerh.

BLITE. Several ſtems riſe from the ſame root, running into many ſhort ramifications. Leaves oblong and obtuſe. Bloſſoms extremely ſmall; green with a yellow anthera. The ſmell is conſiderable, reſembling *Savin.* About *Parker*-river bridge, in *Newbury.* Auguſt.

DIANDRIA.

MONOGYNIA.

LIGUSTRUM. Linn. Gen. Plant. 18.

PRIM Privet. A ſhrub. Leaves in pairs. Bloſſoms white. Berries black, In *Lynn.* Not very common in a wild ſtate. June.

It

It makes excellent hedges. The berries, gathered as ſoon as they are ripe, dye wool and ſilk of a good and durable green, with the addition of alum.

CIRCÆA. Linn. Gen. Plant. 24.

Circæa caule adſcendente, racemo unico. Syſt. Nat.

ENCHANTERS NIGHTSHADE. Bloſſoms variegated. Among buſhes in a moiſt, rich ſoil. July.

VERONICA. Linn. Gen. Plant. 25.

Veronica racemis lateralibus: pedicellis pendulis, foliis linearibus integerrimis. Syſt. Nat.

PIMPERNEL. Brooklime. Water Speedwell. Bloſſoms whitiſh or purpliſh. In ſwamps. June—July.

Veronica.

ONE FLOWER. Stem ſomewhat procumbent. Leaves orbicular; oppoſite on ſhort pedicles. Bloſſoms ſolitary, ſupported on ſhort flower ſtalks riſing from the *axillæ* of the leaves: they are ſmall; white, ſtriated with purple. By the way-ſide. May—July.

GOLDENPERT. The *calix* conſiſts of one leaf; tubular. The limb deeply divided into five ovate, acuminated ſegments; with two ſmall leaves growing on the outſide of the cup, oppoſite the two upper ſinuſes. *Corolla* one petal; tube very long; angular; border divided into four circular, patent, emarginated ſegments; lapping. The upper ſegment largeſt: the lower ſmalleſt. *Stamina* two ſhort filaments riſing from the tube, near together, below the upper ſegment; ſhorter than the tube. *Antheræ* circular; flattiſh; adhering together. *Germen* ovate.

Stile cylindrical; erect; of the length of the Stamina. *Stigma* concave; circular; bent downward. *Capſule* ovate; two cells; two valves. *Seeds* numerous; very ſmall.

The ſtem round; erect. Leaves ſtrap-ſhaped; oppoſite; entire. Bloſſoms ſingle; on flower-ſtalks riſing from the *axillæ* of the leaves; yellow. Around the ſhore of *Wenham* pond. Auguſt.

BASTARD-PEPPERGRASS. The *calix* conſiſts of a perianthium of four erect, concave leaves; the margin coloured; two of them larger, which ſtand oppoſite. Deciduous. *Corolla* none. *Stamina* two ſubulated filaments with antheræ; ſtand oppoſite; of the length of the calix. *Antheræ* ſimple. There are four other ſhorter filaments without antheræ; one on each of the ſides of the fertile filaments. *Germen* circular; compreſſed; emarginated. *Stile* very ſhort. *Stigma* blunt and jagged. *Capſule* circular; compreſſed; emarginated; two cells; four valves. Two flat *ſeeds*; the edges tumid.

Stems round; branched. Radical leaves deeply indented; ſtem leaves lanceolate and ſlightly ſerrated. Bloſſoms very ſmall; on fruit-ſtalks forming a long open ſpike at the extremities of the branches. Borders of fields. July—Sept.

UTRICULARIA. Linn. Gen. Plant. 29.

Utricularia nectario conico. Syſt. Nat. *Lentibularia.* Ray. Syn. *Millefolium aquaticum flore luteo galericulato.* Park.

BLADDERWORT. Common hooded Milfoil. The roots are very ſmall, ſwimming in the water, and ſeem ſcarcely to touch the ground. They ſend off numerous branched fibres, beſet with ſmall membranaceous bladders, appearing like black ſeeds. Bloſſoms yellow. Ponds with a muddy bottom. Auguſt.

Utricularia

Utricularia nectario carinato. Syſt. Nat.

PURPLE BLADDERWORT. *Leſſer hooded Milfoil.* The roots are jointed. Bladders leſs than the former ſpecies. Bloſſoms pale yellow. In muddy ponds. Auguſt.

VERBENA. Linn. Gen. Plant. 30.

Verbena diandra ſpicis longis, calicibus ariſtatis, foliis ovatis ſerratis. Syſt. Nat.

VERVAIN. *Simplers Joy.* The ſtems are quadrangular. Leaves ſtand oppoſite. Bloſſoms in a long cloſe ſpike; pale blue. Common by road-ſides. July—Sept. There are two or three varieties of this ſpecies of the *Verbena* very common.

It is ſaid that the Surgeons of the *American* army, at a certain period when a ſupply of medicine could not be obtained, ſubſtituted a ſpecies of the *Verbena* for an emetic and expectorant, and found its operation kind and beneficial.

LYCOPUS. Linn. Gen. Plant. 31.

Lycopus foliis æqualiter ſerratis. Syſt. Nat.

WATER HOREHOUND. *Gipſie.* The ſtem four cornered. Leaves oppoſite. Bloſſoms whitiſh; ſurrounding the ſtem at the joints. Borders of meadows. Auguſt.

This plant has been miſtaken for a ſpecies of the *Veronica*, and is generally known by the name of *Paul's Betony.* It is ſaid the juice will give a permanent colour to linen, wool and ſilk, that will not waſh out.

TRIANDRIA.

MONOGYNIA.

IRIS. Linn. Gen. Plant. 57.

Iris corollis imberbibus, germinibus trigonis, caule ancipiti. Syſt. Nat.

BLUE-FLAG.

BLUE-FLAG. The leaves are ſword-ſhaped. Bloſſoms blue variegated with white, yellow and purple. In wet meadows. June.

A decoction of the freſh roots is a powerful cathartic, and will ſometimes produce evacuations when other means fail; but it is too draſtic for common uſe. The juice of the freſh roots may be given in doſes of 60 or 80 drops every two hours. Dr. *Withering* ſays the freſh roots of the yellow water flag have been mixed with food of ſwine bitten by a mad dog, and they eſcaped the diſeaſe, when others, bitten by the ſame dog, died raving mad. The root loſes moſt of its acrimony by drying.

XYRIS? Linn. Gen. Plant 59.

YELLOWEYED-GRASS. The *corolla* conſiſts of three ovate, patent, entire petals. The claws narrow; of the length of the *calix.* *Nectaria* three filiform filaments between the petals, longer than the calix, terminating in numerous long hairs. Three very ſhort *filaments* riſing from the petals in the mouth of the bloſſom. *Capſule* membranaceous; one cell; three valves; oblong; compreſſed on one ſide. The other parts agree with *Linnæus*'s deſcription.

The ſtem flattiſh; naked; erect. Radical leaves narrow; tapering to a point. Bloſſoms in an head on the ſummit of the ſtem; bright yellow. On banks of ponds. Auguſt.

CYPERUS. Linn. Gen. Plant. 61.

Cyperus culmo triquetro, umbellæ ſpiculis capitatis oblongis ſeſſilibus, involucris longiſſimis ſerrato-aſperis? Syſt. Nat.

GALANGALE. In open ſwamps. Auguſt.

SCIRPUS. Linn. Gen. Plant. 62.

Scirpus culmo tereti nudo, ſpicis ovatis pluribus pedunculatis terminalibus. Syſt. Nat.

BULLRUSH.

BULLRUSH. In ponds and rivers. Auguſt.

When properly cured it makes very neat bottoms to chairs; but they will be much ſtronger mixed with the leaves of the cat's tail flag, though ſomewhat coarſer.

Scirpus culmo triquetro nudo acuminato, panicula ſpicis conglomerata laterali. Syſt. Nat.

THREE CORNERED RUSH. Banks of ponds and rivers. Aug.

ERIOPHORUM. Linn. Gen. Plant. 63.

Eriophorum culmis folioſis teretibus, foliis planis, ſpica erecta. Syſt. Nat. *Gramen juncoides lanatum alterum danicum.* Park.

COTTONGRASS. Puſſy. Moſſy meadows. May.

The down of the heads has been uſed for ſtuffing pillows and making wicks of candles.

The indigenous graſſes of the ſecond order are numerous, but the limits of this paper would not admit of their being inſerted. A deſcription of theſe and other native graſſes may be the ſubject of another paper.

TRIGYNIA.

MOLLUGO. Linn. Gen. Plant. 99.

Mollugo foliis verticillatis cuneiformibus acutis, caule ſubdiviſo decumbente, pedunculis unifloris. Syſt. Nat. *Mollugo foliis ſæpius ſeptenis lanceolatis.* Gronov.

CARPET-WEED. Stem divided into numerous branches, ſpreading on the ground. Bloſſom: greeniſh white; in cluſters at the joints. About pathways. July.

TETRANDRIA.

MONOGYNIA.

ARUM Americanum, *betæ folio.* Cateſb. Nat. Hiſt.

SCUNK CABBAGE. Scunkweed. The calix conſiſts of a very large, permanent *Spatha*; of a thick, porous ſubſtance, approaching

proaching to an ovate form; open on one side, and bellied out on the opposite; the margin auriculated at the base, and somewhat twisted at the apex. The *Spadix* within the *Spatha.* The florets numerous, placed around the receptacle in an oval form; and are so compact as to appear like a solid body, thick set with small, regular protuberances on its surface. No *Calix. Corolla* four erect, very thick, narrow, obtruncated petals. *Stamina* four flattish filaments rising from the receptacle; longer than the corolla. *Antheres* oblong. *Germen* convex. *Stile* cylindrical; rather longer than the stamina. *Stigma* bifid. *Seeds* large; roundish; single; inclosed within the receptacle.

The first appearance of this singular plant is the flower. After the flower is arrived to a state of perfection, the leaves appear at a small distance from the flower stalk, in a conic form, very closely rolled together. As they rise they expand; nearly ovate; supported on foot stalks. The plant has no stem. The globe of flowers is nearly of the colour of the spatha, which is beautifully variegated with scarlet and yellow. Common in swamps and borders of meadows. April—May.

This plant, which is found native no where but in *North-America,* has been considered by botanists as a species of the *Arum.* But the florets are hermaphrodite, having each of them distinct and perfect corolla, stamina and pistil. It therefore belongs to the first order of this class, and is to be arranged among the aggregate flowers with a common perianthium. The fructification so essentially differs from all the genera of this order, it must, undoubtedly, be considered as a new genus. The vulgar name, by which it is, here, generally known, is taken from its very rank and disagreeable smell, nearly resembling that of a scunk or polecat.

The

The roots dried and powdered are an excellent medicine in aſthmatic caſes, and often give relief when other means are ineffectual. It may be given with ſafety to children as well as to adults; to the former, in doſes of four, five or ſix grains, and to the latter, in doſes of twenty grains and upwards. It is given in the fit, and repeated as the caſe may require. This knowledge is ſaid to have been obtained from the Indians, who, it is likewiſe ſaid, repeat the doſe after the paroxiſm is gone off, ſeveral mornings, then miſs as many, and repeat it again; thus continuing the medicine until the patient is perfectly recovered. It appears to be antiſpaſmodic, and bids fair to be uſeful in many other diſorders. In collecting the roots particular care ought to be taken that the *white hellebore, or poke root*, which ſome people call ſcunk weed, be not miſtaken for this plant, as the conſequence might be fatal. There is an obvious diſtinction—the hellebore has a ſtalk, but the ſcunk cabbage has none.

CEPHALANTHUS. Linn. Gen. Plant. 105.

Cephalanthus foliis oppoſitis terniſque. Syſt. Nat.

GLOBE-FLOWER SHRUB. Pond Dogwood. Button Buſh. The florets form a perfect globe, and when the fruit ſtalk is ſeparated it does not readily appear in what part of the globe it was inſerted. The bloſſoms are ſnow-white, fragrant and beautiful when in full bloom. Common in watery ſwamps and pondholes. July—Auguſt.

HEDYOTIS. Linn. Gen. Plant. 118.

Hedyotis foliis lineari-lanceolatis, caule herbaceo dichotomo, pedunculis geminis. Syſt. Nat.

VENUS PRIDE. Bloſſoms white or bluiſh. It ſpreads over paſtures and fields, in large beds, and gives them a white appearance. May—June.

MITCHELLA. Linn. Gen. Plant. 126.

PARTRIDGEBERRY. The ſtems trailing. Leaves orbicular-cordate; oppoſite, with large white veins. Bloſſoms white. In thick woods and ſwamps. June—July.

PLANTAGO. Linn. Gen. Plant. 133.

Plantago, foliis ovatis glabris, ſcapo tereti, ſpica floſculis imbricatis. Syſt. Nat.

PLANTAIN. Common near roads and foot-paths. June—July.

The leaves are applied, by the common people, to inflamed ſores and ſwellings. The bruiſed leaves they apply to freſh cuts.

Plantago foliis lanceolato-ovatis pubeſcentibus ſubdenticulatis, ſpicis laxis pubeſcentibus, ſcapo angulato. Syſt. Nat.

VIRGINIA PLANTAIN. In graſs land. Not common. May—June.

Plantago foliis ſemicylindraceis integerrimis baſi lanatis, ſcapo tereti. Syſt. Nat.

SEA PLANTAIN. In ſalt marſhes. July.

It is ſaid to be cultivated and ſown with clover in *North-Wales* in *Great-Britain*, and greedily eaten by horſes and cows: but *Linnæus* ſays, that cows are not fond of it.

SANGUISORBA. Linn. Gen. Plant. 136.

Sanguiſorba ſpicis longiſſimis. Syſt. Nat. *Pimpinella maxima.* Cornutus.

AMERICAN BURNET. *Snakeweed*. The leaves are winged; very long. The ſmall leaves ſerrated. The filaments and antheræ are white. In rich moiſt ground. July—September.

Its

Its growth is generally luxuriant, and makes good fodder for cattle.

CISSUS. Linn. Gen. Plant. 137.

Cissus foliis ovatis nudis setaceo—serratis. Syst. Nat.

PIGEON-BERRY BUSH. The shrub grows six or eight feet high. Leaves opposite. Blossoms in broad-topped spikes; white. Common on the banks of brooks and rivers. June.

Pigeons feed on the berries, which has been the occasion of its trivial name.

MEADOW BLUEBELLS. The *calix* is a permanent perianthium of one leaf; tubular. Tube quadrangular; limb divided into four acute, erect segments. The *corolla* one petal. Tube between funnel and bell-shaped; longer than the calix; divided into four roundish, patent segments, with ciliated margins. *Nectaria* four prominent glands in the base of the corolla. *Stamina* four triangular, erect filaments; inserted into the corolla, and of the length of the calix. *Antheræ* oblong; erect. *Germen* oblong; within the tube. *Stile* short. *Stigma* bifid; flat; circular. *Capsule* oblong, quadrangular; one cell; four valves. *Seeds* numerous; ovate; adhering to the angles of the capsule.

The stem nearly round; erect; branched. Leaves ovate; opposite; half embracing the stem. Blossoms large; single; terminating; bright blue. In moist land. Not common. September.

The blossoms open about ten o'clock in the morning, and close by two in the afternoon.

CORNUS. Linn. Gen. Plant. 139

Cornus herbacea, ramis nullis. Syst. Nat.

CORNEL. *Dogberry.* The ſtem is quadrangular. Leaves oval; oppoſite. From the *axillæ* of the upper leaves, two other leaves are ſent off, ſpreading laterally, which give the appearance of ſix leaves at a joint. Bloſſoms white. In woodland. May—June.

OLDENLANDIA. Linn. Gen. Plant. 143.

DOGWOOD. The leaves are ovate; acuminated. Bloſſoms in broad-topped ſpikes; white. In ſwamps and banks of rivers. July.

DIGYNIA.

HAMAMELIS. Linn. Gen. Plant. 155.

WITCH-HAZEL. The leaves are nearly inverſly ovate. Bloſſoms yellow: ſtand three or four together on ſhort flower ſtalks. In loamy land. Sept.—October.

This ſingular ſhrub does not commonly bloom until its leaves are deſtroyed by froſt, when its numerous bloſſoms make a gay and agreeable appearance; and continue until the weather becomes very cold, often until ſnow falls. The germen endures the ſeverity of our winters uninjured; for the fruit does not ripen until the next September, the time of its bloſſoming again, when ripe fruit and bloſſoms will be found on the ſame tree.

The Indians conſidered this tree as a valuable article in their *materia medica.* They applied the bark, which is ſedative and diſcutient, to painful tumors and external inflammations. A cataplaſm of the inner rind of the bark, is found to be very efficacious in removing painful inflammations of the eyes. The bark chewed in the mouth is, at firſt, ſomewhat bitter, very ſenſibly aſtringent, and then leaves a pungent, ſweetiſh taſte, which will remain for a conſiderable time. The ſpecific qua-

lities

lities of this tree seem, by no means, to be accurately ascertained. It is, probably, possessed of very valuable properties.

CUSCUTA. Linn. Gen. Plant. 156.

Cuscuta floribus pedunculatis. Syst. Nat.

DODER. *Devil's Guts.* Among flax. July.

This plant is well known to farmers, who often have their fields of flax greatly injured by its twining about the stalks. It is parasitical. When it has ascended the stalk of flax, or whatever plant is next to it, a number of very small papillæ are sent off from the inner surface of the vine, which insinuate themselves into the bark of the plant. The root then decays, and it receives its nourishment from the plant which it twines about. The whole plant is bitter; and it affords a pale reddish colour.

TRAILING COCKSPUR. *Calix* none; except the corolla be called the calix. *Corolla* one petal; flat; coloured without and within. Limb deeply divided into four ovate acuminated segments. Deciduous. *Stamina* four short, filiform, erect filaments; standing upon the corolla. *Antheræ* globular. *Germen* below; double. Stiles two; erect; passing through the base of the corolla. *Stigmata* globular. Two *seeds*, or nuts, contained in a rind thick set with hooked spines.

The generic characters of this plant approach those of the *Aphanes*, but seem so essentially to differ as not to admit its being placed under that genus.

The stem trailing; four square; the edges tumid, and beset with short, hooked spines. Leaves lanceolate; six at a joint. Blossoms reddish white; placed in the *axillæ* of the leaves. Borders of brooks and ditches. August.

UPRIGHT

UPRIGHT COCKSPUR. Stems erect; quadrangular. Leaves ovate; four at a joint. Stem-leaves rough: somewhat woolly. Blossoms white. Open wood land. June.

TETRAGYNIA.

POTAMOGETON. Linn. Gen. Plant. 160.

Potamogeton foliis oblongo-ovatis petiolatis natantibus. Syst. Nat. *Fontalis major latifolia vulgaris.* Park.

PONDWEED. Blossoms in spikes; yellowish. In ponds and rivers. August.

The leaves afford an agreeable shade to pickerel.

PENTANDRIA.

MONOGYNIA.

CYNOGLOSSUM. Linn. Gen. Plant. 168.

Cynoglossum staminibus corolla brevioribus, foliis lato—lanceolatis tomentosis sessilibus. Syst. Nat.

HOUNDSTONGUE. Blossoms pale blue. Road sides in *Dedham.* July.

It has a very disagreeable smell. Dr. *Withering* observes, that both the root and leaves have been suspected to possess narcotic properties; but that others will not admit the fact.

SYMPHYTUM. Linn. Gen. Plant. 170.

Symphytum foliis ovato—lanceolatis decurrentibus. Syst. Nat. *Symphytum magnum.* Raii. Syn.

COMFREY. Blossoms yellowish white. In moist land. Not common growing wild. June.

It is cultivated in gardens; and though it is sometimes found growing wild, there seems to be some doubt whether it be indigenous.

The

The roots are much uſed by the common people for ſprains. They are glutinous and mucilaginous. The leaves give a grateful flavour to cakes and panadoes.

CORTUSA. Linn. Gen. Plant. 181.

Cortuſa calycibus corollam excedentibus. Syſt. Nat.

BEARSEAR SANICLE. The ſtems are round; erect. Leaves oblong in pairs. Bloſſoms yellow. In moiſt ground. July.

HOTTONIA. Linn. Gen. Plant. 186.

Hottonia pedunculis verticillato—multifloris. Syſt. Nat. *Millefolium aquaticum floridum ſeu viola aquatica.* Park. *Hottonia.* Boerh.

WATER VIOLET. *Featherfoil.* Leaves winged, ſpreading on the ſurface of the water in a ſtellate form. Bloſſoms white. In ſtanding waters and ditches. May—June.

LYSIMACHIA. Linn. Gen. Plant. 188.

Lyſimachia foliis quaternis ſubſeſſilibus, pedunculis quaternis unifloris. Syſt. Nat.

YELLOW WILLOWHERB. *Pimpernel.* *Looſeſtriſe.* Stem round; hairy. Leaves ovate. Bloſſoms bright yellow. In wood land. June.

MEADOWSWEET. *Moneywort.* Stems erect. Leaves oblong; five or ſix at a joint; marked with white or red ſpecks. Bloſſoms ſingle; on long flower ſtalks; yellow. Borders of meadows, or brooks. June.

ANAGALLIS. Linn. Gen. Plant. 189.

Anagallis foliis indiviſis, caule procumbente. Syſt. Nat. *Anagallis flore phœniceo.* Park.

PIMPERNEL. Bloſſoms red. In clayey ground. June.

Anagallis

Anagallis foliis sinuatis. Syst. Nat.

GROUNDSTAR. Blossoms white, tinged with red. Amongst grass by the way side. May—Aug.

AZALEA. Linn. Gen. Plant. 195.

Azalea foliis ovatis, corollis pilosis, staminibus longissimis. Syst. Nat.

AMERICAN HONEYSUCKLE. Swamp Pink. Blossoms in a kind of tuft at the termination of the branches. They are white; but the deep red globules at the ends of the hairs on the corolla and stamina give the appearance of a red tinge. Common in low, swampy land. June.

This shrub, when in full bloom, makes an elegant appearance. The blossoms are fragrant, and have been made into conserves. It is easily propagated in gardens, and may doubtless be improved by cultivation. We have few exotic flowering shrubs superior to it.

CONVOLVULUS. Linn. Gen. Plant. 198.

Convolvulus foliis sagittatis utrinque acutis, pedunculis unifloris. Syst. Nat.

BINDWEED. Small Convolvulus. Blossoms white or striped. In corn fields. July.

Convolvulus foliis sagittatis postice truncatis, pedunculis tetragonis unifloris. Syst. Nat. *Convolvulus major albus.* Park.

GREAT CONVOLVULUS. Two floral leaves close to the calix. Blossoms white; or white and red. Common in hedges, and by stone walls. July.

Catesby, in his history of the *Carolinas*, mentions an Indian who daubed himself with the juice of a species of the Convolvulus, and then handled a rattle-snake without receiving injury.

Scammony.

Scammony, Dr. *Withering* says, is the inspissated juice of a species of Convolvulus so much resembling this, that they are with difficulty distinguished. Can it then, says he, be worth while to import Scammony from *Aleppo*, at a considerable annual expence, when a medicine, with the very same properties, grows spontaneously in many of our hedges ? If the preparation of Scammony would be a saving to *England*, it must certainly be a much greater to *America*, in proportion to the quantity used. Besides, as the imported Scammony is often very impure, and as there is so much difference in the purgative virtue of some masses of it, and that of others, that it is seldom to be depended upon alone in extemporaneous practice, might it not be prepared here much purer, and be more uniform in its virtue ? Notwithstanding the roots of the Convolvulus is a very acrid purgative to the human race, hogs will eat it in large quantities without any ill effects.

IPOMOEA. Linn. Gen. Plant. 199.

Ipomoea foliis cordatis integerrimis glabris lacunosis, pedunculis bifloris. Syst. Nat.

AMERICAN JASMINE. Leaves stand opposite. Blossoms yellow, tinged with red. Among hazel bushes. Very rare. July.

AMERICAN TEA. The *calix* a very small permanent rim, surrounding the receptacle ; scarcely visible. *Corolla* one petal ; tubular. Limb divided into five acuminated segments ; rolled inward. *Nectaria* five hooded petals, with long, filiform claws, inserted into the corolla below the sinuses of the segments ; erect ; longer than the segments of the corolla. *Stamina* five subulated filaments standing upon the corolla just below

below the petals of the nectarium. Antheræ globular; covered by the hooded petals of the nectarium. *Germen* above; globular. *Stile* cylindrical; erect; ſhorter than the ſtamina. *Stigma* trifid. *Capſules* three; each one cell; one valve. *Seeds* one in each cell; ovate compreſſed.

Stems woody. Leaves ovate; ſerrated; acuminated. Bloſſoms in long, terminating, open ſpikes; ſnow white. By fences, and among buſhes in loamy land. July.

The leaves of this ſhrub have been much uſed by the common people, in ſome parts of the country, in the room of *India* tea; and is, perhaps, the beſt ſubſtitute the country affords. They immerſe the freſh leaves in a boiling decoction of the leaves and branches of the ſame ſhrub, and then dry them with a gentle heat. The tea, when the leaves are cured in this way, has an agreeable taſte, and leaves a roughneſs on the tongue ſomewhat reſembling that of the bohea tea.

CAMPANULA? Linn. Gen. Plant. 201.

Campanula foliis ſubovatis integerrimis, caulibus diffuſis. Syſt. Nat.

VENUS LOOKING-GLASS. Bloſſoms yellow. On high land. July.

PHYTEUMA. Linn. Gen. Plant. 203.

Phyteuma capitulo ſubfolioſo, foliis omnibus lanceolatis. Syſt. Nat.

RAMPION. Bloſſoms white with blue veins. Moiſt land. July.

LONICERA. Linn. Gen. Plant. 210.

Lonicera racemis terminalibus, foliis ſerratis. Syſt. Nat.

HONEYSUCKLE. Baſtard Cherry. Bloſſoms yellow, tinged with red. Among buſhes in loamy land. June.

VERBASCUM.

VERBASCUM. Linn. Gen. Plant. 217.

Verbascum foliis decurrentibus utrinque tomentosis. Syst. Nat.

MULLEIN. Blossoms in long terminating spikes ; yellow. Common in old fields. July.

Verbascum foliis amplexicaulibus oblongis glabris, pedunculis solitariis. Syst. Nat.

MOTH MULLEIN. Blossoms yellowish white. By the road sides in *Lynn.* July.

DATURA. Linn. Gen. Plant. 218.

Datura pericarpiis spinosis erectis ovatis. Syst. Nat.

APPLEPERU. *Stramonium.* *Thornapple.* Blossoms white with a tinge of purple. The upper leaves have been observed to rise up and enclose the blossoms at night. Common by the way sides. August.

This plant is said to be an exotic, and that it is not found growing at any great distance from the sea. The seeds taken internally bring on delirium ; large doses would, no doubt, prove fatal. The leaves applied to the feet, or part affected, have been found efficacious in removing spasms ; and applied in cataplasms give ease in external inflammations. An ointment prepared from the leaves gives ease likewise in external inflammations and hæmorrhoids. The *Edinburgh* College direct an extract to be prepared by evaporating the expressed juice of the leaves. Its medical properties undoubtedly merit attention. None of the herbivorous animals will eat it.

HYOSCYAMUS. Linn. Gen. Plant. 219.

Hyoscyamus foliis amplexicaulibus. Syst. Nat.

HENBANE. Blossoms purple and brown ; clammy. Common amongst rubbish, and by road sides. July.

The ſeeds, the leaves, and the roots, Dr. *Withering* obſerves, are all poiſonous. Madneſs, convulſions, and death, are the general conſequence. In a ſmaller doſe, they occaſion giddineſs and ſtupor. The *Edinburgh* College order the expreſſed juice of the plant to be evaporated to an extract. In this ſtate, the Doctor ſuppoſes, it may be advantageouſly joined with opium, where the effects of that medicine are deſirable, and coſtiveneſs is to be avoided. There is no doubt, he ſays, of its being a uſeful medicine under proper management. The doſe is from half a ſcruple to half a dram. It is ſaid, that the leaves ſcattered about a houſe will drive away mice.

SOLANUM. Linn. Gen. Plant. 224.

Solanum caule inermi fruteſcente flexuoſo, foliis ſuperioribus haſtatis, racemis cymoſis. Syſt. Nat.

BITTER-SWEET. Bloſſoms purple, with ſpots of white. Common about fences in moiſt land. June.

Boerhaave ſays, it is a medicine far ſuperior to China and Sarſaparilla as a ſweetner and reſtorative. *Linnæus* ſays, an infuſion of the young twigs is an admirable medicine in acute rheumatiſms, inflammations, fevers, and ſuppreſſion of the lochia. Dr. *Hill* ſays, he has found it very efficacious in the aſthma.

Solanum caule inermi herbaceo, foliis ovatis dentato—angulatis, umbellis nautantibus. Syſt. Nat.

NIGHTSHADE. Bloſſoms white. Berries black. Common among rubbiſh. July.

Dr. *Withering* ſays, from one to three grains of the leaves infuſed in boiling water, and taken at bed time, occaſions a copious perſpiration; increaſes ſecretions by the kidneys, and generally

generally purges more or leſs the following day. Theſe properties, judiciouſly applied, render it capable of doing eſſential ſervice in ſeveral diſeaſes. But its effects on the nervous ſyſtem are ſo uncertain, and ſometimes ſo conſiderable, that it muſt ever be adminiſtered with the greateſt caution. The leaves applied externally, eaſe pain and abate inflammations.

TIVERTWIG. American *Mezerion.* The generic characters do not entirely agree with the Solanum; but they approach nearer to this than any other genus. Stems woody; twining about ſhrubs or trees; branched. Leaves ovate; ſerrated; acuminated. Bloſſoms greeniſh white. Berry pale red. In hedges and wood land. June.

It is uſed with ſucceſs in diſcuſſing indurated tumors. Farmers apply it to ſwellings in cows bags. Phyſicians of diſtinguiſhed characters ſay, that the roots anſwer as valuable a purpoſe, in venereal caſes, as the Mezerion.

RIBES. Linn. Gen. Plant. 247.

Ribes inerme, racemis piloſis, floribus oblongis. Syſt. Nat.

BLACK CURRANT. Bloſſoms yellowiſh. Berries black. It is rarely found growing naturally here, but is cultivated in gardens. In ſome parts of the eaſtern country it is ſaid to be found in great plenty, particularly near *Kennebeck-river.*

A jelly made of the fruit is celebrated in the Philoſophical Tranſactions of the Royal Society for curing very bad kinds of ſore throat. It has been found to anſwer very well here, particularly in that ſpecies of the ſore throat in which the tonſils ſuppurate. It ought to be applied early and frequently. When the fruit could not be obtained, an infuſion of the bark, ſweetened with honey, and uſed as a gargle, has proved beneficial.

Dr.

Dr. *Withering* ſays, the juice of the berries is frequently boiled down into an extract, with the addition of a ſmall proportion of ſugar, which is called rob, and is much uſed in ſore throats, but chiefly in thoſe of the inflammatory kind. An infuſion of the young roots is uſeful in fevers of the eruptive kind; and in the dyſenteric fevers of cattle. The fruit is often put into rum inſtead of black cherries. The tender leaves will give a tinge to rum nearly reſembling brandy.

Ribes ramis aculeatis, petiolorum ciliis piloſis, baccis hirſutis. Syſt. Nat.

GOOSE BERRY. Bloſſoms greeniſh white. Berries rediſh, or white. Common in moiſt hedges, and banks of ditches. May.

The fruit is very agreeable, either as nature preſents it, or made into a jelly. It is much uſed in tarts. An equal weight of picked Gooſe Berries and pure ſugar put over the fire, will ſpontaneouſly ſeparate a liquor which becomes a moſt agreeable jelly. The fruit of the wild Gooſe Berry may be greatly improved by cultivation.

HEDERA. Linn. Gen. Plant. 249.

Hedera foliis ovatis lobatiſque. Syſt. Nat. *Hedera trifolia Canadenſis.* Corn.

POISON IVY. Bloſſoms white, with purple or black veins. Berries black. Common in moiſt hedges and meadows. June.

It aſcends trees adhering by numerous linear tendrils, which are ſent off from the body of the ſtem, inſinuating their ſharp ends into the bark of the tree. It produces the ſame kind of inflammations and eruptions, in certain conſtitutions, as the poiſon wood tree. A milky juice exſudes from the ſtalks and leaves,

leaves, which will ſtain linen a deep and unfading black. This juice is ſaid to have been uſed by the Indians in ſtaining the hardeſt ſubſtances a deep and permanent black. Country people employ it in making ink. Some have ſuppoſed its properties are not inferior to thoſe of the *Japan* varniſh tree.—It is undoubtedly worthy of attention.

Hedera foliis quinatis ovatis ſerratis. Syſt. Nat.

WOODBINE. Ivy. Bloſſoms greeniſh white. Berries dark brown. Moiſt wood land. July.

It is planted by walls and buildings, upon which it will aſcend, ſupporting itſelf by a ſingular kind of degitate tendrils.

VITIS. Linn. Gen. Plant. 250.

Vitis foliis cordatis dentato—ſerratis utrinque nudis Syſt. Nat.

GRAPE. Bloſſoms white. Berries white or purple. Common in moiſt land, and ſwamps.

DIGYNIA.

APOCYNUM. Linn. Gen. Plant. 269.

Apocynum caule rectiuſculo herbaceo, foliis ovatis utrinque glabris, cymis terminalibus. Syſt. Nat.

DOGSBANE. Umbrella weed. Bloſſoms white, ſtriped with red. Borders of wood land. July.

Apocynum caule erecto fruteſcente, foliis lanceolato—ovalibus, corollis acutis : fauce villoſis. Syſt. Nat.

RIVER SWALLOWWORT. Bloſſoms yellowiſh white. At *Winnipeſoket-falls*, in *Providence-river*. July.

ASCLEPIAS. Linn. Gen. Plant. 270.

Aſclepias foliis lanceolato—ellipticis, caule ſimplici glabro, nectarii corniculis conniventibus. Syſt. Nat.

SILKWEED.

SILKWEED. Bloſſoms rediſh. Common by the road ſides, and in paſtures. July.

The ſeeds are contained in large pods, and are crowned with white down, extremely fine and ſoft, reſembling ſilk, which has occaſioned the name of Silkweed. It may be carded and ſpun into an even thread, which makes excellent wickyarn. The candles will burn equally free, and afford a clearer light than thoſe made of cotton wicks. They will not require ſo frequent ſnuffing, and the ſmoke of the ſnuff is leſs offenſive. The texture of the down is weak, but ſufficiently ſtrong for dipped candles. If greater ſtrength ſhould be neceſſary, a ſmall quantity of cotton wool may be mixed with the down. Large quantities may be eaſily collected, and the tallow-chandlers might, doubtleſs, be ſupplied for leſs than half the price of cotton yarn.

Aſclepias foliis ovatis ſubtus villoſis, caule ſimplici, umbellis erectis, nectariis reſupinatis. Syſt. Nat.

INDIAN HEMP. Bloſſoms rediſh. In moiſt land. July.

The fibres of the bark are ſtrong, and capable of being wrought into a fine ſoft thread; but it is very difficult to ſeparate the bark from the ſtalk. It is ſaid to have been uſed by the Indians for bow-ſtrings.

Aſclepias foliis lanceolatis glabris, caule ſimplici, umbellis erectis lateralibus ſolitariis. Syſt. Nat.

SWALLOWWORT. Bloſſoms white. About fences in moiſt land. July.

Aſclepias foliis lanceolatis, caule ſuperne diviſo, umbellis terminalibus congeſtis. Syſt. Nat.

MONEYWORT. Bloſſoms purple. In old fields. July.

CHENOPODIUM.

CHENOPODIUM. Linn. Gen. Plant. 273.

Chenopodium foliis ovatis dentatis acutis, racemis ramosis nudis. Syst. Nat.

SOWBANE. Fruit green or reddish. About barns. August.

SALSOLA. Linn. Gen. Plant. 275.

Salsola herbacea decumbens, foliis subulatis spinosis scabris, calycibus marginatis axillaribus. Syst. Nat.

KELPWORT. Blossoms greenish. On the sea shore. September.

Salsola herbacea erecta, foliis subulatis spinosis lævibus, calycibus ovatis. Syst. Nat.

GLASSWORT. Blossoms greenish. On the sea shore. July.

ULMUS. Linn. Gen. Plant. 281.

Ulmus foliis duplicato-serratis : basi inæqualibus. Syst. Nat.

ELM. Blossoms in broad-topped spikes. Bark of the trunk cracked and rough. In loamy land. April.

A decoction of the inner bark, drank freely, is said to carry off the water in dropsies. The bark dried and ground to powder, hath been mixed with meal, in *Norway*, to make bread in times of scarcity.

Ulmus foliis æqualiter serratis : basi inæqualibus. Syst. Nat.

SMALL ELM. Common in moist land and swamps.

GOLDEN VINE. *Calix* a perianthium with five small, obtuse segments. *Corolla* one petal ; bell-shaped. Limb divided into five obtuse, patent segments. *Stamina* five erect filaments inserted into the corolla at the sinuses of the segments. *Antheræ* simple.

fimple. *Germen* large ; globular. *Stiles* two ; very fhort. *Stigmata* fimple. *Capfule* globular ; two cells ; four valves. *Seeds* two ; globular.

The ftem is of the fize of a pack-thread ; twining. It is parafitical ; attaching itfelf to whatever vegetable is next to it, by numerous papillæ. It has many branches. No leaves. Bloffoms in bunches ; placed in the *axillæ* of the branches ; fnow white. Common in hedges, and among bufhes in moift ground. July.

SANICULA. Linn. Gen. Plant. 289.

Sanicula foliis radicalibus compofitis : foliolis ovatis. Syft. Nat.

SANICLE. Bloffoms greenifh. By ftone walls, and among bufhes. June.

LASERPITIUM. Linn. Gen. Plant. 306.

Laferpitium foliolis trilobis incifis. Syft. Nat.

GREAT LASERWORT. Wild Angelica. Bloffoms white. On high land. Not common. June.

ANGELICA. Linn. Gen. Plant. 309.

Angelica foliis æqualibus ovatis incifo—ferratis. Syft. Nat.

ANGELICA. American *Mafterwort.* Bloffoms greenifh white. Borders of fields in moift land. July.

It is warm, acrid and aromatic. The ftems are frequently candied by the country people.

SIUM. Linn. Gen. Plant. 310.

Sium foliis pinnatis, umbellis terminalibus. Syft. Nat.

WILD PARSLEY. Water parfnip. Bloffoms white. In watery places. July.

TRIGYNIA.

TRIGYNIA.

RHUS. Linn. Gen. Plant. 331.

Rhus foliis pinnatis ovatis acuminatis ferratis fubtus tomentofis. Syft. Nat.

HAIRY SUMACH. Bloffoms greenifh white. Fruit fcarlet. About fields. July.

Rhus foliis pinnatis ferratis lanceolatis utrinque nudis. Syft. Nat.

VELVET SUMACH. Bloffoms greenifh white. Fruit in large, ovate, clofe panicles; crimfon. Common in a loamy foil. July.

Rhus foliis pinnatis integerrimis, petiolo membranaceo articulato. Syft. Nat.

DWARF SUMACH. Bloffoms greenifh white. Panicles open. Fruit pale red. In rocky ground. July.

Thefe fpecies of Sumach are moderately aftringent. An infufion of the berries, fweetened with honey, is fometimes ufed for a gargle in fore throats, and for cleanfing the mouth in putrid fevers. The country people employ them in feveral kinds of dyes. With copperas or vitriol they give a good black; but it foon grows rufty. They are ufed in the preparation of *Morocco* and other leather. *Carver* fays, the Indians, in order to render their tobacco more agreeable in fmoking, mix with it equal quantities of the leaves of Sumach.

Rhus foliis pinnatis integerrimis, petiolo integro. Syft. Nat. *Arbor* Americana *alatis foliis fucco venenato.* Plukenet. *Toxicodendron foliis alatis, fructu purpureo pyriformi fparfo.* Catefby.

POISON WOOD. *Swamp Sumach.* Bloffoms whitifh. Panicles open. Fruit yellowifh; fmall; pair-fhaped. Common in fwamps. June.

 The

The milky juice ſtains linen a dark brown. The whole ſhrub is, in a high degree, poiſonous to certain conſtitutions. The poiſon will be communicated by touching or ſmelling any part of the ſhrub. In about forty-eight hours inflammation appears on the ſurface of the ſkin, in large blotches; principally on the extremities, and on the glandulous parts of the body. Soon after, ſmall puſtules riſe in the inflamed parts, and fill with watery matter, attended with very conſiderable burning and itching. In two or three days the eruptions ſuppurate; after which the inflammation ſubſides, and the ulcers heal in a ſhort time. It operates, however, ſomewhat differently in different conſtitutions; and what is ſingular, ſome conſtitutions are incapable of being poiſoned with it at all. It has been obſerved, that perſons of irritable habits are the moſt liable to receive it.

Rhus foliis ternatis: foliolis petiolatis ovatis nudis integerrimis, caule radicante. Syſt. Nat.

CREEPING IVY. Bloſſoms whitiſh. In meadows. June. The juice will ſtain linen a deep black. It is leſs poiſonous than the Poiſon Wood.

The Abbé *Sauvages* ſtained linen a black colour with the juice of the *Toxicodendron Caroliniarum foliis pinnatis, floribus minimis herbaceis*, which it retained, notwithſtanding a great number of waſhings in lye. The juice adhered, without the leaſt acrimony, to the cloth, with more force than any other known preparation. The Abbé *Mazeas* made trial of the juice of the *Hedera trifolia Canadenſis*. Corn. The inſtant, he ſays, the cloth was expoſed to the ſun, it became the fineſt black he had ever ſeen. It was put into a boil of ſoap, and after being dried,

dried, into a ſtrong lye of aſhes, but neither of them made the leaſt alteration. Mr. *Philip Miller* ſays, the *American* Toxicodendron, with the juice of which the Abbé *Sauvages* ſtained his linen, is the ſame ſpecies of plant from which the inhabitants of *Japan* procure the varniſh with which they ſtain all their utenſils: and recommends it to the inhabitants of the (then) *American* colonies to collect this varniſh, which, he ſays, may not only produce much profit to themſelves, but alſo become a national advantage. But Mr. *John Ellis* inſiſts upon there being a difference in their ſpecific characters. [*Philoſ. Tranſ. Royal Society. Vol.* xlix. *p.* 157, 161, 866.]

The leaves of ſome of our Poiſon Wood trees are entirely ſimilar to Dr. *Kæmpfer*'s figure of the *Sitz, vel Sitz dſju, vulgo urus ſeu urus noki. Arbor vernicifera legitima folio pinnato, Juglandis fructu, recemoſo Ciceris facie*: and the only difference between the leaf of one ſpecies of our Sumach and the leaf of the varniſh tree, raiſed from ſeeds ſent to the Royal Society, is, that the middle part, and not the baſe of the leaf of Sumach, is ſerrated. Conſidering the great profits that have accrued from the varniſh tree, to the two large empires of *China* and *Japan*, and the advantages of a deep, permanent and incorroſive black dye, it muſt be thought worth while to make experiments on all our ſpecies of the Hedera and Rhus. If we ſhould fail of ſucceſs with reſpect to the native plants, there can be no doubt but that the varniſh tree of *Japan*, could the ſeeds be procured in a vegetitive ſtate, would flouriſh in *America*.

VIBURNUM. Linn. Gen. Plant. 332.

Viburnum foliis cordatis ſerratis venoſis ſubtus tomentoſis. Syſt. Nat.

MEALTREE.

MEALTREE. Bloſſoms white. Berries black. In moiſt wood land. June.

Viburnum foliis lobatis, petiolis glandulosis. Syſt. Nat.

WATER ELDER. Bloſſoms white. Berries red. In *Glouceſter,* in wet land. June.

CASSINE? Linn. Gen. Plant. 333.

Caſſine foliis oblongis ſerratis. Syſt. Nat.

WINTERBERRY. The number of filaments is from five to ſeven, and the number of ſeeds equal to the number of filaments. Bloſſoms white. Berries red, and generally remain on the ſhrub through the winter. In ſwamps. June.

SAMBUCUS. Linn. Gen. Plant. 334.

Sambucus cymis quinquepartitis, caule arboreo. Syſt. Nat.

ELDER. Bloſſoms white. Berries black. In ſwamps, and moiſt land. May.

Dr. *Withering* obſerves, that the inner green bark is purgative, and may be uſed with advantage where acrid purgatives are requiſite. In ſmall doſes it is diuretic, and hath done eminent ſervice in obſtinate glandular obſtructions, and in dropſies. If ſheep that have the rot are placed in a ſituation where they can get at the bark and the young ſhoots, they will ſoon cure themſelves. The leaves are purgative like the bark, but more nauſeous. The inner bark and leaves are ingredients in ſeveral cooling ointments. A decoction of the flowers, taken internally, is ſaid to promote expectoration in pleuriſies. If the flowers are freſh gathered, they looſen the belly. Externally, they are uſed in fomentations to eaſe pain and abate inflammation. They will give a flavour to vinegar. A rob prepared from the

berries

berries is a gentle opener, and promotes perſpiration. An infuſion of the dried berries is given to children. The flowers kill turkeys, and the berries are poiſonous to poultry. The freſh leaves laid round young cucumbers, melons or cabbages, are a good preſervative againſt worms and inſects. It is ſaid, if turnips, cabbages, fruit trees or corn, (which are ſubject to blights from a variety of inſects) are whipped with the green leaves and branches of Elder, the inſects will not attack them. The green leaves are ſaid to drive away mice.

ALSINE. Linn. Gen. Plant. 342.

Alſine petalis bipartitis, foliis ovato—cordatis. Syſt. Nat.

CHICKWEED. Leaves oppoſite. Bloſſoms white; open about nine in the morning, and cloſe at noon. Common in gardens, and rich cultivated ground. June—September.

If it be boiled when young, it can hardly be diſtinguiſhed from ſpring ſpinach. What is called the ſleep of plants is very apparent in the Chickweed. At night the leaves approach, in pairs, ſo near as to incloſe, within their upper ſurface, the rudiments of the young ſhoots and the ends of the branches. As the dew goes off in the morning they expand.

PENTAGYNIA.

ARALIA. Linn. Gen. Plant. 346.

Aralia caule petioliſque aculeata, foliolis inermibus villoſis. Syſt. Nat.

BERRY-BEARING ANGELICA. *Shot Buſh.* *Pigeon Weed.* Bloſſoms white. Berries black. Common in new plantations. July.

Aralia caule folioſo herbacco lævi. Syſt. Nat.

PETTYMORREL.

PETTYMORREL. *Life of Man.* Bloſſoms greeniſh white. Berries black. In moiſt, rich wood land. July.

It is aromatic. The berries give ſpirits an agreeable flavour. The bark of the root and berries are a good ſtomachic. It is ſaid to have been much uſed by the Indians for medical purpoſes.

Aralia.

SARSAPARILLA. The roots extend a long way juſt under the ſurface of the ground. Stems naked; divided into three leaf-ſtalks. Leaves ovate; acuminated; ſerrated; three or five on a leaf-ſtalk, in a winged form. Bloſſoms in a globular umbel, riſing from the *axillæ* of the leaf-ſtalks; white. Berries red. Common in loamy wood land. May.

The roots are aromatic and nutritious. They have been found beneficial in debilitated habits. It is ſaid the Indians would ſubſiſt upon them, for a long time, in their war and hunting excurſions. They make an ingredient in diet drinks.

STATICE? Linn. Gen. Plant. 348.

Statice caule nudo paniculato tereti, foliis lævibus. Syſt. Nat.

MARSH ROSEMARY. Bloſſoms blue. Common in marſhes. July.

The roots are powerfully aſtringent. A decoction of them is given, and uſed as a gargle, with ſucceſs, in cankers and ulcerated ſore throats.

DROSERA. Linn. Gen. Plant. 351.

Droſera ſcapis radicatis, foliis orbiculatis. Syſt. Nat.

SUNDEW. *Roſa Solis.* Bloſſoms white. In moſſy meadows. July—Auguſt.

The

The whole plant is ſufficiently acrimonious to erode the ſkin. But Dr. *Withering* ſays, ſome ladies know how to mix the juice with milk, ſo as to make it an innocent and ſafe application to remove freckles and ſunburn. The juice will deſtroy warts and corns. If the juice be put into a ſtrainer, through which the warm milk from the cow is poured, and the milk ſet by for a day or two to become aceſcent, it acquires a conſiſtancy and tenacity—neither the whey nor the cream will ſeparate. In this ſtate it is uſed by the inhabitants in the north of *Sweden*, and called an extremely grateful food.

HEXANDRIA.

MONOGYNIA.

PONTEDERIA. Linn. Gen. Plant. 361.

Pontederia foliis cordatis, floribus ſpicatis. Syſt. Nat.

PICKERELWEED. Blue Spike. Bloſſoms blue. Common on the borders of ponds and rivers. July.

LILIUM. Linn. Gen. Plant. 371.

Lilium foliis verticillatis, floribus reflexis, corollis revolutis. Syſt. Nat.

MARTAGON. Curl-flowered Lily. Bloſſoms yellow, ſpotted with black. In *Taunton*, and very common in the ſtate of *Rhode-Iſland.* July—Auguſt.

Lilium foliis verticillatis, floribus reflexis, corollis campanulatis. Syſt. Nat.

YELLOW LILY. Bloſſoms yellow, with black ſpots. Common in meadows. July—Auguſt.

Lilium foliis verticillatis, flore erecto, corolla campanulata. Syſt. Nat.

RED LILY. Bloſſoms red, ſpotted with black. Common on borders of meadows. July.

UVULARIA. Linn. Gen. Plant. 373.

Uvularia foliis ſeſſilibus. Syſt. Nat.

BELLWORT. *Sweet-ſmelling* Solomon's *Seal.* Jacob's *Ladder.* Bloſſoms whitiſh. Common in wood land. May.

The young ſhoots may be eaten as aſparagus. The roots are nutritious, and are uſed in diet-drinks.

ORNITHOGALUM. Linn. Gen. Plant. 377.

Ornithogalum ſcapo anguloſo diphyllo, pedunculis umbellatis ſimplicibus. Syſt. Nat.

BETHLEMSTAR. Bloſſoms yellow. Common in graſs land and amongſt buſhes. May.

The bulbous roots are nutritious and wholeſome. It makes beautiful edgings for borders in gardens.

CONVALLARIA. Linn. Gen. Plant. 383.

Convallaria foliis amplexicaulibus plurimis, racemo terminali ſimplici? Syſt. Nat.

SOLOMON's SEAL. Leaves alternate, and are rather ſeſſile than embracing the ſtem. Bloſſoms white. Berries red, or black. In rich wood land. May.

The young ſhoots may be eaten as aſparagus. The roots are nutritious.

Convallaria foliis cordatis. Syſt. Nat.

HAREWORT. *Adder's Tongue.* One radical leaf; two ſtem-leaves. Bloſſoms white. Berries red. Common amongſt buſhes in moiſt land. May.

In this plant we have an inſtance of the wrong application of an *Engliſh* name.—It is called *Adder's Tongue*, and miſtaken

for

for one of the *ferns,* which is known by that name in *England.*

ALETRIS. Linn. Gen. Plant 387.

Aletris floribus erectis. Syſt. Nat.

UNICORN. Bloſſoms white. On high land in *Killingſly*, in the ſtate of *Connecticut.* July.

It is ſaid to be uſeful in chronic rheumatiſms.

ACORUS. Linn. Gen. Plant. 392.

SWEET FLAG. *Spicewort.* The leaves are thick; narrow; two-edged. Bloſſoms greeniſh. Common in watery places. July.

The roots and bloſſoms are aromatic and pungent. The dried roots are carminative. They are frequently grated into water, and given to children for pain in the ſtomach and bowels. The *Turks* candy the roots, and think they are a preſervative againſt contagion.

BERBERIS. Linn. Gen. Plant. 399.

Berberis pedunculis racemoſis. Syſt. Nat.

BARBERRY. *Pipperidge Buſh.* Bloſſoms yellow. Common. July.

The berries are uſed for pickles. Boiled with ſugar, they form a moſt agreeable jelly. They are uſed likewiſe as a dry ſweet-meat, and in ſugar-plumbs. An infuſion of the bark in white wine is purgative. The roots boiled in lye dye wool yellow. In *Poland,* they dye leather of the moſt beautiful yellow with the bark of the root. The inner bark of the ſtems dyes linen of a fine yellow, with the aſſiſtance of alum. It is ſaid, that rye and wheat will be injured by this ſhrub, at the diſtance of three or four hundred yards; but only when it is

in bloſſom, by means of the *farina fœcundans* being blown upon the grain, which prevents the ears from filling.

TRIGYNIA.

RUMEX. Linn. Gen. Plant. 407.

Rumex floribus hermaphroditis : valvulis integris graniferis, foliis lanceolatis undulatis acutis. Syſt. Nat.

CURLED DOCK. In fields. July.

Rumex floribus hermaphroditis : valvulis dentatis nudis, pedicellis planis reflexis. Syſt. Nat.

NARROW DOCK. About barns and in fields. July.

The roots of both theſe ſpecies are ſomewhat cathartic. The ſeeds are ſaid to have been given with great advantage in the dyſentery. The freſh roots bruiſed and made into an ointment, or decoction, cure the itch.

Rumex floribus hermaphroditis : valvulis integerrimis nudis foliis cordatis glabris acutis. Syſt. Nat.

WATER DOCK. In muddy bottom brooks. Not common. July.

The Indians uſed this root with great ſucceſs in cleanſing foul ulcers. It is ſaid they endeavoured to keep it a ſecret from the *Europeans.* Dr. *Withering* ſays, he ſaw an ill-conditioned ulcer in the mouth, which had deſtroyed the palate, cured by waſhing the mouth with a decoction of this root, and drinking a ſmall quantity of the ſame decoction daily.

Not having opportunity to examine this plant ſince Dr. *Withering*'s Botany came into my hands, the circumſtances he mentions, reſpecting the *American* and *Britiſh* ſpecies, have not been particularly attended to. At the time it was examined, it appeared to correſpond with the ſpecific characters of *Linnæus,* which are here given.

Rumex

Rumex floribus dioicis, foliis oblongis sagittatis. Syst. Nat.

SORREL. Common in old fields. June.

MELANTHIUM. Linn. Gen. Plant. 410.

Melanthium petalis unguiculatis. Syst. Nat.

QUAFFIDILLA. Blossoms greenish yellow. In moist ground. Not common. May.

MEDEOLA. Linn. Gen. Plant. 411.

Medeola foliis verticillatis, ramis inermibus. Syst. Nat.

INDIAN CUCUMBER. Blossoms greenish yellow. In rich wood land. June.

The roots, which are of a conic form, are esculent and of an agreeable taste. The Indians made them a part of their food.

POLYGYNIA.

ALISMA. Linn. Gen. Plant. 418.

Alisma foliis ovatis acutis, fructibus obtuse trigonis. Syst. Nat.

WATER PLANTAIN. Blossoms white, with yellow antheræ. In wet places. June.

HEPTANDRIA.

MONOGYNIA.

TRIENTALIS. Linn. Gen. Plant. 419.

Trientalis foliis lanceolatis integerrimis. Syst. Nat.

WINTERGREEN. Blossoms white. Common in wood land. May.

OCTANDRIA.

MONOGYNIA.

RHEXIA. Linn. Gen. Plant. 423.

Rhexia foliis sessilibus serratis. Syst. Nat.

ROBINHOOD.

ROBINHOOD. Leaves hairy. Bloſſoms pale red. In moiſt ground. July—Auguſt.

OENOTHERA. Linn. Gen. Plant. 424.

Oenothera foliis ovato—lanceolatis planis, caule lævi ſubvilloſo. Syſt. Nat.

SUNDROP. Bloſſoms in a kind of ſpike; yellow. They open about eleven o'clock, and, commonly, not more than one on the ſame day. In wet meadows. June.

Oenothera hirta, foliis ſupra glabris. Syſt. Nat.

PRIMROSE. Leaves oblong; ſerrated. Bloſſoms in a large ſpike; terminating; yellow. Common in old fields. July.

This plant is very generally known by the name of *Scabious*, and ſeems to have been miſtaken for the *Scabioſa arvenſis* of *Linnæus*. No ſpecies of *Scabious* has been found native in this part of the country.

EPILOBIUM. Linn. Gen. Plant. 426.

Epilobium foliis ſparſis lineari—lanceolatis. Syſt. Nat.

WILLOWHERB. Stamina erect. Bloſſoms in a long diffuſe ſpike; purple. By fences in moiſt land. July.

Epilobium foliis oppoſitis lanceolatis integerrimis, petalis emarginatis, caule erecto. Syſt. Nat.

MEADOW WILLOWHERB. Bloſſoms reddiſh. Moiſt land. July.

VACCINIUM. Linn. Gen. Plant. 434.

The ſpecies of this genus are generally known, and are too many to admit a particular deſcription in this paper. The following are indigenous.

The

The *Black Whortleberry*. The *Bilberry* or *Blueberry*. These shrubs are low when they grow on high land, but tall in swamps. The *White Whortleberry*. The *Red Whortleberry*. The fruit of these species are agreeable to children, either eaten by themselves, or in milk, or in tarts and jellies. The *Choke Whortleberry*. The fruit is unpalatable; but its great degree of astringency may, one day or other, recommend it to the attention of physicians. The *Craneberry*, or *Mossberry*. These berries make an agreeable tart. By drying them a little in the sun, and then putting them in a close vessel, or stopping them up in dry bottles, they may be kept good for many years.

TRIGYNIA.

POLYGONUM. Linn. Gen. Plant. 445.

Polygonum caule simplicissimo monostachyo, foliis ovatis in petiolum decurrentibus. Syst. Nat.

BISTORT. *Snakeweed.* Blossoms red. In wet meadows. August.

The root is said to be one of the strongest vegetable astringents.

Polygonum floribus hexandris semidigynis, foliis lanceolatis, stipulis submuticis. Syst. Nat.

ARSMART. *Water Pepper.* Blossoms white. Common both in dry and moist land. August.

It occasions severe smarting when rubbed on the flesh. The taste is acrid and burning. It dyes wool yellow. Dr. *Withering* says, it cures little aphthous ulcers in the mouth.—That the ashes mixed with soft soap is a nostrum, in a few hands, for dissolving the stone in the bladder; but perhaps not preferable to other caustic preparations of the vegetable alkali.

Polygonum

Polygonum floribus hexandris, digynis, ſpicis ovato-oblongis, foliis lanceolatis, ſtipulis ciliatis. Syſt. Nat.

HEARTSEASE. Spotted Arſmart. The leaves have a dark ſpot on their upper ſurface, in form of a creſcent. Bloſſoms reddiſh white. Common about barns. Auguſt.

It will dye woollen cloth yellow, after the cloth has been dipped in a ſolution of alum.

Polygonum floribus octandris trigynis axillaribus, foliis lanceolatis, caule procumbente herbaceo. Syſt. Nat.

KNOTGRASS. Bloſſoms reddiſh white. Common by the road ſides. June—September.

Polygonum foliis ſagittatis, caule aculeato. Syſt. Nat.

SICKLEWEED. Bearded Arſmart. Bloſſoms white, tinged with red. In wet meadows. Auguſt.

Polygonum foliis cordatis, caule volubili, floribus planiuſculis. Syſt. Nat.

BLACK BINDWEED. Wild Bean. Bloſſoms greeniſh white. About barns and in corn fields. July—Auguſt.

ENNEANDRIA.

MONOGYNIA.

LAURUS. Linn. Gen. Plant. 452.

Laurus foliis enerviis ovatis utrinque acutis integris annuis. Syſt. Nat.

FEVER BUSH. Bloſſoms yellowiſh. Berries red. Common in moiſt land. May.

This ſhrub is aromatic. A decoction of the ſmall twigs makes an agreeable drink in ſlow fevers, and is much uſed by the country people. It is ſaid the Indians eſteemed it highly for its medicinal virtues.

Laurus

Laurus foliis trilobus integrisque. Syst. Nat.

SASSAFRAS. Blossoms greenish white. Common in loamy land. May.

It is generally a shrub, but sometimes grows into a large tree. The leaves fall early. The bark of the tree is aromatic, and has been substituted by people in the country for spice. It is said, that bedsteads made of this wood, will never be infested with bugs. It is said to be an excellent diuretic and diaphoretic, and therefore efficacious in obstructions of the viscera, cachexies, scorbutic complaints and in the venereal disease. An infusion of the bark of the roots makes a grateful drink. A very pungent, hot oil is extracted from it, which is said to possess most of the virtues of the wood. It has been exported in considerable quantities to *Europe*.

DECANDRIA.

MONOGYNIA.

PANTHEON. American *Senna*. The *Calix*, if properly any, a narrow husky border. *Corolla* three petals standing in a papilionaceous form. *Vexillum* very large; erect; slightly divided into three segments. *Alæ* narrow; obtuse; as long as the vexillum. *Carina* none. *Stamina* ten filaments; erect; separate; longer than the corolla. *Antheræ* orbicular. *Germen* ovate; hairy. *Stile* cylindrical; longer than the stamina. *Stigma* capitate; sending off several long hairs. *Capsule* ovate; five valves; five cells. Seeds many; small.

It is a small shrub. Leaves spear-shaped, and do not commonly appear until the shrub is in full bloom. Blossoms in tufts at the termination of the branches; bluish purple, cloud-

ed with dark red. It makes an elegant appearance amongſt flowering ſhrubs in gardens. On the declivity of hills near ſwamps. May.

MONOTROPA. Linn. Gen. Plant. 477.

Monotropa caule unifloro, flore decandro. Syſt. Nat.

BIRDSNEST. Bloſſoms yellow. About *Great Oſſapy* pond, in the ſtate of *New-Hampſhire.* July.

JUSSIÆA. Linn. Gen. Plant. 478.

WOOD PLANTAIN. Rattle-Snake Plantain. The germen within the corolla. The other characters agree with *Linnæus's* deſcription. The ſtems are erect, with only one or two ſmall leaves; five petals in the flowers. Radical leaves large; ovate; ſlightly indented; ſpreading on the ground. Bloſſoms in open ſpikes; terminating; greeniſh white. In rich wood land. June.

It is ſaid to cure the bite of a rattle-ſnake, by applying the chewed leaves to the wound, and ſwallowing a quantity of the juice. It commonly grows plentifully near their dens. Wherever theſe dangerous ſerpents haunt, nature ſeems to have provided an effectual antidote againſt their venom.

KALMIA. Linn. Gen. Plant. 482.

Kalmia foliis ovatis, corymbis terminalibus. Syſt. Nat.

GREAT LAUREL. Wintergreen. Spoonhaunch. Bloſſoms white, tinged with red. In moiſt, rocky paſtures. June—July.

The Indians are ſaid to have made ſmall diſhes, ſpoons, and other utenſils, out of the roots. They are ſometimes employed by people in the country for ſimilar purpoſes. They are large, of

of a soft texture, and easily wrought when green; but when thoroughly dry, become very hard and smooth. Under cultivation it makes a most beautiful flowering shrub.

Kalmia foliis lanceolatis, corymbis lateralibus. Syst. Nat.

WINTERGREEN. *Dwarf Laurel. Ivy. Lambkill.* It is an ever-green. Blossoms variegated. Common in cold, wet land. June—July.

If the leaves are eaten by sheep, they prove fatal. Some have supposed, it is not owing to any poisonous, but an indigestive quality in the leaves, occasioned by the large quantity of resin they contain. Others say, that, in many instances, none of the leaves are found in the stomach, but evident marks of corosive poison. It makes an elegant appearance, properly disposed amongst other flowering shrubs, in a border. But its being so common, and the disadvantage it usually appears under in a wild state, have prevented its being introduced into gardens.

ANDROMEDA. Linn. Gen. Plant. 485.

Andromeda racemis secundis nudis, corollis rotundo-ovatis. Syst. Nat.

WHITE PEPPERBUSH. Blossoms white. Common in swamps. June.

It is generally called *Osier*, which is the *English* name of the *Salix viminalis* of *Linnæus*, one of the species of the *Willow*. It is used for fish-flakes, and, as the wood is very hard and durable, is one of the best shrubs employed for that purpose.

Andromeda.

GARDROBE. *Bog Ever-green.* Fruit-stalks single; in the axillæ of the leaves. Corolla ovate. Leaves lanceolate; alternate.

ternate. Bloſſoms pendent; white. Common in fens and quagmires. April—May.

ARBUTUS. Linn. Gen. Plant. 488.

Arbutus caule erecto, foliis glabris integerrimis, baccis polyſpermis. Syſt. Nat.

FOXBERRY. Checkerberry. Bloſſoms white. Berries red. Common in pine and ſhrub oak land. It blooms in July and Auguſt, but the fruit is not ripe until the next ſpring.

It is in a very ſmall degree aromatic. The leaves are much celebrated by the common people as a diuretic and ſweetner of the blood, but are of very little efficacy. It makes an ingredient in their diet-drinks. The berries are rather of an agreeable taſte, and are ſometimes eaten by children in milk.

CLETHRA. Linn. Gen. Plant. 489.

SWEET PEPPERBUSH. A ſhrub. Leaves inverſely ovate; ſerrated. Bloſſoms in long ſpikes; terminating; white. Common in moiſt land and ſwamps. July—Auguſt.

PYROLA. Linn. Gen. Plant. 490.

Pyrola ſtaminibus adſcendentibus, piſtillo declinato. Syſt. Nat.

CONSUMPTION-ROOT. Bloſſoms white. In wood land. July.

Pyrola floribus racemoſis diſperſis, ſtaminibus piſtilliſque rectis. Syſt. Nat.

RHEUMATISM-WEED. Bloſſoms pale red. In wood land. It abounds near *White-Mountains.*

It is ſaid to have been conſidered by the Indians as an effectual remedy in rheumatiſms.

FALSEVINE.

FALSEVINE. The *calix* is a permanent perianthium of one leaf; bell-ſhaped. Limb divided into ten ſmall, unequal, erect ſegments. *Corolla* five narrow, patent petals; inſerted into the mouth of the cup. *Stamina* ten ſubulated filaments; longer than the corolla. *Antheræ* oblong. *Germen* above; globular. *Stile* cylindrical; ſhorter than the cup. *Stigma* capitate and jagged. Capſule globular; three cells; three valves. Seeds many; ſmall; ovate.

The ſtem is angular; reclining. If the end touches the ground it takes root. Leaves ſpear-ſhaped; entire. Bloſſoms on ſhort flower-ſtalks riſing from the *axillæ* of the leaves; deep purple. In wet meadows, and on the borders of ponds and rivers. July.

This plant, if it be eaten in large quantities, will occaſion abortion in all kinds of herbivorous animals. It is frequently mowed with meadow-graſs, and ſeems to be grateful food in the winter to all ſorts of cattle. But in ſome inſtance it has deprived farmers of almoſt all the increaſe of their ſtock in the ſpring. Thoſe who are acquainted with its baneful effects, are careful to ſeparate it from their hay, when they rake it.

DIGYNIA.

SAXIFRAGA. Linn. Gen. Plant. 494.

Saxifraga foliis lanceolatis denticulatis, caule nudo paniculato, floribus ſubcapitatis. Syſt. Nat.

GOLDEN SAXIFRAGE. Bloſſoms rediſh.

TRIGYNIA.

CUCUBALUS. Linn. Gen. Plant. 502.

Cucubalus calycibus ſubgloboſis glabris reticulato-venoſis, capſulis trilocularibus, corollis ſubnudis. Syſt. Nat.

CAMPION.

CAMPION. Bladder Behen. Bellweed. Bloſſoms white. On borders of fields in *Lynn.* July.

STELLARIA. Linn. Gen. Plant. 504.

Stellaria foliis linearibus integerrimis, floribus paniculatis. Syſt. Nat.

STITCHWORT. Bloſſoms in panicles; white. Amongſt buſhes. May.

ARENARIA. Linn. Gen. Plant. 505.

Arenaria foliis filiformibus, ſtipulis membranaceis vaginantibus. Syſt. Nat.

SANDWORT. Bloſſoms rediſh white. On the ſea ſhore. Auguſt.

Arenaria foliis ovatis nervoſis ſeſſilibus acutis. Syſt. Nat.

SPURRY. Bloſſoms white. In wood land. July.

PENTAGYNIA.

OXALIS. Linn. Gen. Plant. 515.

Oxalis ſcapo unifloro; foliis ternatis, radice ſquamoſa articulata. Syſt. Nat.

WOOD SORREL. Cuckow-Bread. Sour Trefoil. In rainy weather the leaves ſtand upright, but in dry weather they hang down. Bloſſoms yellow. In ſhady places. May—Auguſt.

Dr. *Withering* ſays, the expreſſed juice depurated properly evaporated, and ſet in a cool place, affords a chryſtalline acid ſalt in conſiderable quantity, which may be uſed wherever vegetable acids are wanted. The *London* College directs a conſerve to be made with the leaves beaten with thrice their weight of fine ſugar. The juice is gratefully acid. An infuſion of the leaves is an agreeable liquor in ardent fevers.

SPERGULA.

SPERGULA. Linn. Gen. Plant. 319.

Spergula foliis verticillatis, floribus pentandris. Syſt. Nat.

PINEY. *Spurry.* Bloſſoms white. In cultivated ground, eſpecially among flax. Auguſt.

DECAGYNIA.

PHYTOLACCA. Linn. Gen. Plant. 521.

Phytolacca floribus decandris. Syſt. Nat.

GARGET. *Cunicum.* *Skoke.* American *Nightſhade.* Bloſſoms white, tinged with red. Berries black. Common by road ſides. July.

The juice of the berries gives a fine purple tincture to paper, but it ſoon fades. The berries are employed in dyes by the country people, but the colours are not laſting. They would make a moſt beautiful purple dye, if ſome method could be found for fixing the colour. The roots are emetic and cathartic. An ounce of the dried root, infuſed in a pint of wine, and given to the quantity of two ſpoonfuls, frequently operates very kindly as an emetic. In ſome caſes it is preferable to moſt other emetics, as it hardly alters the taſte of the wine. The roots are applied to the hands and feet in ardent fevers. Farriers give a decoction of them to drench cattle, and apply them, in form of poultice, for diſcuſſing tumors. The young ſhoots boiled, are hardly to be diſtinguiſhed from ſpinach, and are nutritious and wholeſome. Poultry are fond of the berries; but, if eaten in large quantities, will give their fleſh a diſagreeable flavour.

DODECANDRIA.

MONOGYNIA.

PORTULACA. Linn. Gen. Plant. 531.

Portulaca foliis cuneiformibus floribus ſeſſilibus. Syſt. Nat.

PURSLANE. The number of the ſtamina are inconſtant. Bloſſoms yellow. In corn-fields. July.

It

It is eaten as a pot-herb, and eſteemed by ſome as little inferior to aſparagus.

LYTHRUM. Linn. Gen. Plant. 532.

Lythrum foliis alternis linearibus, floribus hexandris. Syſt. Nat.

WILD HYSSOP. *Graſſpoly.* Bloſſoms purple. In wet land. June—July.

DIGYNIA.

AGRIMONIA. Linn. Gen. Plant. 534.

Agrimonia foliis caulinis pinnatis : foliolis undique ſerratis : omnibus minutes interſtinctis, fructibus hiſpidis. Syſt. Nat.

AGRIMONY. The number of ſtamina from five to twelve. Bloſſoms on long terminating ſpikes ; yellow. By fences. July.

It is ſaid the Indians uſed an infuſſion of the roots in inflammatory fevers, with great ſucceſs. Dr. *Hill* ſays, an infuſion of ſix ounces of the crown of the root in a quart of boiling water, ſweetened with honey, and half a pint of it drank three times a day, is an effectual cure for the jaundice. He adviſes to begin with a vomit, afterwards to keep the bowels ſoluble, and to continue the medicine as long as any ſymptoms of the diſeaſe remains.

ICOSANDRIA.

MONOGYNIA.

PRUNUS. Linn. Gen. Plant. 546.

Specific deſcriptions under this genus, as well as that of the *Vaccinium*, are, for the ſame reaſons, omitted. The trees and ſhrubs found growing naturally, are known by the following names.

The

The *Beach*, or *Sea-Side Plumb*. There are ſeveral varieties of this ſpecies growing plentifully on *Plumb-Iſland*. The fruit of ſome of them, when fully ripe, is well-taſted. They are eaſily propagated in gardens, by planting the ſtones in a mixture of beach ſand and loam, and will produce fruit in two or three years.

The *Black Cherry Tree*. It is common, grows large, and the wood, which is ſmooth and hard, is uſed by cabinet-makers in many kinds of work. They have the art of giving it a ſtain which approaches the colour of mahogany. The fruit is rather indifferent in its natural ſtate, but might probably be greatly improved by cultivation. It is infuſed in rum and brandy for the ſake of giving them an agreeable flavour. An infuſion or tincture of the inner bark is given with ſucceſs in the jaundice. The *Small Black Cherry*. The tree is ſmall and ſhrubby, and the fruit not ſo well flavoured as the large black cherry. The *Black Choke Cherry*. A low ſhrub. The *Large Red Cherry*. A ſmall tree. The *Dwarf Red Cherry*, A very low ſhurb. The *Red Choke Cherry*. A ſhrub. The *Small Pale Red Cherry*. A ſmall tree, and the fruit hard and ill-taſted.

The laſt-mentioned cherry tree abounds, where land has been cleared, in the new plantations near *White-Mountains*, but is rarely, if at all, found in the foreſts. Some have aſſerted, that this ſpecies of cherry tree is not found in that part of the country, except in places where the native growth has been deſtroyed. In land, where there is no kind of cherry trees after the old growth, which conſiſts chiefly of ſpruce, pine, beach and birch, (exceedingly tall and large) has been fell and burnt on the ground, there ſprings up, the next ſummer, an immenſe

 number

number of theſe cherry trees. By what means are they produced? The doctrine of equivocal, or ſpontaneous generation, has long been exploded. Nature has not formed the ſeeds for being wafted by the wind. Can it be ſuppoſed ſuch vaſt numbers were ſcattered by birds? Or, upon this ſuppoſition, is there not difficulty in conceiving, that neither the long period of time which moſt of them muſt be ſuppoſed to have laid in the ground, nor the intenſe heat, occaſioned by burning ſuch prodigious piles of wood, ſhould deſtroy their vegetive quality?

DIGYNIA.

CRATÆGUS. Linn. Gen. Plant. 547.

Cratægus foliis cordatis repando-angulatis ſerratis glabris. Syſt. Nat.

HAWTHORN. Bloſſoms white. Fruit red. In dry land. May. It is ſaid that an ardent ſpirit may be diſtilled from the fruit.

Cratægus foliis lanceolato-ovatis ſerratis glabris, ramis ſpinoſis. Syſt. Nat.

THORNBUSH. Bloſſoms white. Fruit red. Common in hedges. May.

PENTAGYNIA.

PYRUS. Linn. Gen. Plant. 550.

Pyrus foliis ſerratis, floribus corymboſis. Syſt. Nat.

BASTARD PEAR. Juniper. A ſhrub which blooms very early in the ſpring, commonly before other trees are leaved out. Bloſſoms white. The fruit is rediſh, ſmall, nearly round, and well taſted. It ripens in June; but birds are ſo fond of it that they rarely ſuffer it to remain until it is ripe. It is eaten by children in milk. Common in moiſt land.

SPIRÆA. Linn. Gen. Plant. 554.

Spiræa foliis lanceolatis obtuſis ſerratis nudis, floribus duplicato-racemoſis. Syſt. Nat.

MEADOW

MEADOW SWEET. Bloſſoms white, tinged with red. In moiſt paſtures. Auguſt.

Spiræa foliis lanceolatis inæqualiter ſerratis ſubtus tomentoſis, floribus duplicato-racemoſis. Syſt. Nat.

QUEEN OF THE MEADOWS. Bloſſoms red or purple. In moiſt paſtures. July—Auguſt.

POLOGYNIA.

ROSA. Linn. Gen. Plant. 556.

Roſa germinibus globoſis hiſpidis, pedunculis ſubhiſpidis, caule aculeis ſtipularibus, petiolis aculeatis. Syſt. Nat.

WILD ROSE. Dog Roſe. Bloſſoms red. Berry pale red. Common in moiſt land. June.

The bloſſoms gathered before they expand, and dried, are aſtringent; but when full blown, are purgative. This ſpecies is generally preferred for conſerves. A perfumed water may be diſtilled from the bloſſoms. The pulp of the berries, beat up with ſugar, makes the conſerve of hepps of the *London* diſpenſatory. The dried leaves of every ſpecies of roſe have been recommended as a ſuſtitute for *India* tea, giving out a fine colour, a ſub-aſtringent taſte, and a grateful ſmell.

RUBUS. Linn. Gen. Plant. 577.

Rubus foliis quinato-pinnatis ternatiſque, caule aculeato, petiolis canaliculatis. Syſt. Nat.

RASPBERRY. Bloſſoms white. Berry pale red. Common by ſtone walls. June.

The fruit is ſub-acid, cooling and extremely grateful. If it be made into ſweet-meat, with ſugar, or formented with wine, the flavour is improved. It is eaten in milk, and with cream and ſugar. Dr. *Withering* ſays, it diſſolves the tartarous con-

cretions of the teeth; but for this purpose it is inferior to the strawberry.

Rubus foliis ternis subtus tomentosis, caule aculeato, petiolis teretibus. Syst. Nat.

BRAMBLE. Upright Brier. Blossoms white. Berry dark brown. In hedges. June.

Rubus foliis ternatis subnudis: lateralibus bilobis, caule aculeato tereti. Syst. Nat.

SMALL BRAMBLE. Blackberry Brier. Dewberry. Blossoms white. Berry black. Common in old fields. June.

Rubus foliis quinato-digitatis ternatisque, caule petiolisque aculeatis. Syst. Nat.

SOWTEAT. Bumblekites. Blossoms white. Berries black. In hedges, and by fences. May—June.

The fruit is pleasant to eat, and communicates a fine flavour to red wine. It is frequently infused in brandy and rum. The green twigs are said to be of great use in dying woollen, silk and mohair black.

Rubus foliis digitatis denis quinis ternatisque, caule inermi. Syst. Nat.

SUPERB RASPBERRY. Blossoms large; in panicles; petals purple; antheræ yellow. Berry redish yellow. In high land on the declivity of hills. It grows plentifully in the new-plantations at the northward. June—September.

The fruit is much larger and more delicious than the common rasberry. It is easily cultivated in gardens; and the large size of the leaves and blossoms give it an elegant appearance. Ripe fruit and blossoms are commonly found on the same panicles.

Rubus

Rubus foliis ſimplicibus cordatis lobatis, caule aculeato decumbente. Syſt. Nat.

BLACKBERRY. Bloſſoms white. Berry black. Common in old fields. May.

The fruit is well taſted. Children are fond of them in milk. They are infuſed in rum and brandy, and give them a flavour little inferior to that of black cherries.

FRAGARIA. Linn. Gen. Plant. 558.

Fragaria flagellis reptans. Syſt. Nat.

STRAWBERRY. Bloſſoms white. Berry red. In fields and paſtures. May.

The fruit in its uncultivated ſtate, if the ſoil be rich, is large and well taſted, but may be greatly improved by culture. The white fruited, double flowering, and other varieties, are produced by cultivation. It is ſub-acid, cooling, and may be eaten in large quantities without offending the ſtomach. Dr. *Withering* ſays, they promote perſpiration, impart a violet ſmell to the urine, and diſſolve the tartarous incruſtations upon the teeth. People afflicted with the ſtone or gout have found great relief by uſing them very freely. *Hoffman* ſays, he has known conſumptive people cured by them. They are univerſally eſteemed a moſt delicious fruit, either eaten alone, or with ſugar or milk.

POTENTILLA. Linn. Gen. Plant. 559.

Potentilla foliis pinnatis ſerratis, caule repente. Syſt. Nat.

MARSH TANSEY. *Silverweed.* Bloſſoms yellow. Borders of marſhes. June.

Potentilla foliis quinatis, caule repente, pedunculis unifloris. Syſt. Nat.

CINQUEFOIL. Fivefinger. Bloſſoms yellow. In old fields. June.

It is mildly aſtringent and antiſeptic. A decoction of it is uſed as a gargle for looſe teeth and ſpungy gums.

GEUM. Linn. Gen. Plant. 561.

Geum floribus erectis, fructu globoſo: ariſtis uncinatis nudis, foliis ternatis. Syſt. Nat.

BENNET. Common Avens. Herb-Bennet. Bloſſoms white or yellow. By fences and borders of fields. July.

Dr. *Withering* ſays, the roots gathered in the ſpring, before the ſtem grows up, and put into ale, give it a pleaſant flavour, and prevent its growing ſour. Infuſed in wine it is a good ſtomachic. When it grows in warm dry ſituations, its taſte is mildly auſtere and aromatic.

Geum floribus nutantibus, fructu oblongo: ariſtis plumoſis. Syſt. Nat.

WATER AVENS. Throatroot. Cureall. Bloſſoms purpliſh. In boggy meadows. May.

The root is powerfully aſtringent. A decoction of it has been uſed, with good ſucceſs, as a gargle, and a drink, in inflammed and ulcerated ſore throats, and cankers. It is ſaid, that the powdered root will cure tertian agues, and that it is much uſed by the *Canadians* for that purpoſe.

POLYANDRIA.

MONOGYNIA.

ACTÆA. Linn. Gen. Plant. 568.

Actæa racemo ovato, fructibus baccatis. Syſt. Nat.

CHRISTOPHER. Baneberries. Bloſſoms white. Berry red. In wood land and ſhady places. May.

The

The berries are exceedingly poiſonous. Dr. *Withering* ſays, the plant is powerfully repellant; and that the root is uſeful in ſome nervous caſes, but it muſt be adminiſtered with caution. It is ſaid, that toads, allured by the fœtid ſmell of this plant, reſort to it.

SANGUINARIA. Linn. Gen. Plant.

BLOODROOT. Puccoon. Leaves roundiſh; deeply indented. Stems naked; ſupporting ſingle flowers. Bloſſoms white. In rich wood land. April.

When the freſh root is broken, a juice iſſues, in large drops, reſembling blood. The Indians uſed it for painting themſelves, and highly eſteemed it for its medical virtues. It is emetic and cathartic, but muſt be given with caution. An infuſion of the root in rum or brandy makes a good bitter. If it be planted in rich ſhady borders, it flouriſhes well in gardens; and the large leaves and bloſſoms make an agreeable appearance ſoon after the froſt is out of the ground.

CHELIDONIUM. Linn. Gen. Plant. 572.

Chelidonium pedunculis umbellatis. Syſt. Nat.

CELANDINE. Bloſſoms yellow. Common by fences and amongſt rubbiſh. June—Auguſt.

This plant is very acrimonious. The juice deſtroys warts, and cures ringworms. Diluted with milk, it is ſaid to conſume white opake ſpots upon the eyes.

SARRACENIA. Linn. Gen. Plant. 578.

Sarracenia foliis gibbis. Syſt. Nat.

SARRACENE. Side-Saddle Flower. Hallow-leaved Plant. The leaves are tubular, ſomewhat reſembling the horn of an ox inverted. The aperture at the top is horizontal and circular,

with

with a broad patent, foliaceous appendage, extending two-thirds of the way round it. A ſimilar appendage runs down the concave ſide to the root. The cavities of the leaves are large, and generally contain a quantity of water. They ſeem to be deſigned by nature for reſervoirs, from which the plants may be conſtantly ſupplied with moiſture. The ſtems are erect and naked. Bloſſoms ſingle, terminating and reclining; petals red; the ſtigma, which covers the diſk, rediſh green. In moiſt land, eſpecially in fens and quagmires. May—June.

NYMPHÆA. Linn. Gen. Plant. 579.

Nymphæa calyce magno pentaphyllo. Syſt. Nat.

WATER YELLOW LILY. Toad Lily. Bloſſoms yellow. In ponds and rivers. June.

Nymphæa foliis cordatis integerrimis, calyce quadrifido. Syſt. Nat.

POND LILY. Water Lily. Bloſſoms white. In ponds and rivers. July.

The flowers open about ſeven in the morning, and cloſe about four in the afternoon. A conſerve is made of the leaves of the bloſſoms. The roots of both ſpecies are much uſed, in form of poultices, for producing ſuppuration in boils and painful tumors, and are very efficacious. The root of the water yellow lily is generally preferred. Dr. *Withering* ſays, the roots of the pond lily are uſed in *Ireland*, and in the iſland of *Jura*, to dye a dark brown.

BIXA. Linn. Gen. Plant. 581.

BASS WOOD. White Wood. Suggumug. The ſtigma is quadrifid. Bloſſoms white. In woods. Not common. July.

This

This tree is of a middling ſize, and the wood very white and ſoft. When it is perfectly dry it ſwims on the water like cork. It is uſed by turners for making bowls, trenchers and diſhes.

CISTUS. Linn. Gen. Plant. 598.

Ciſtus herbaceus exſtipulatus, foliis omnibus alternis lanceolatis; caule adſcendente. Syſt. Nat.

AMERICAN CISTUS. Little Sunflower. Bloſſoms yellow, and the diſk commonly turned towards the ſun from morning until night. In dry paſtures. June.

PENTAGYNIA.

AQUILEGIA. Linn. Gen. Plant. 605.

Aquilegia nectariis rectis, ſtaminibus corolla longioribus. Syſt. Nat.

COLUMBINE. Honey Horns. Bloſſoms red. Amongſt rocks in dry land. May.

Cultivation renders it equal in beauty to any of the exotic columbines. It makes an elegant appearance among them, and adds to the variety in flower-borders.

NIGELLA ? Linn. Gen. Plant. 606.

GOLDENTHREAD. Mouth Root. The number of *petals* from five to ſeven; commonly ſix. *Nectaria* ſix cups; ſupported on filament nearly as long as the ſtamina. *Germina* from three to ſeven; commonly ſix.

The roots thread-ſhaped; running; bright yellow. Leaves grow by threes; circular; ſcolloped. Stems erect; naked. Bloſſoms ſolitary; terminating; white. Common in ſwamps. May.

The roots are aſtringent, and of a bitteriſh taſte. Chewed in the mouth they cure apthas and cankerous ſores. It is frequently an ingredient in gargles for ſore throats.

 POLYGYNIA

POLYGYNIA.

ANEMONE. Linn. Gen. Plant. 614.

Anemone foliis trilobis integerrimis. Syst. Nat.

LIVERWORT. Bloſſoms white, tinged with red. In woods and ſhady places. April.

Anemone pedunculo nudo, ſeminibus ſubrotundis hirſutis. Syſt. Nat.

WHITE ANEMONE. Bloſſoms white. Amongſt buſhes, and in ſhady places. May.

Anemone ſeminibus acutis, foliolis inciſis, caule unifloro. Syſt. Nat.

WOOD ANEMONE. Bloſſoms white, tinged with purple. In woods and newly-cleared land. May.

CLEMATIS. Linn. Gen. Plant. 616.

Clematis foliis ternatis, foliolis cordatis ſerrato-angulatis, ſcandentibus. Syſt. Nat.

TRAVELLER's JOY. Virgin's Bower. Bloſſoms white. Banks of brooks and river's. July.

RANUNCULUS. Linn. Gen. Plant. 619.

Ranunculus foliis radicalibus reniformibus crenatis ſublobatis, caulinis tripartitis lanceolotis integerrimis, caule multifloro. Syſt. Nat.

PILEWORT. Burwort. Bloſſoms yellow. By fences. September.

Ranunculus foliis radicalibus ſubrotundo-cordatis crenatis; caulinus digitatis dentatis, caule multifloro. Syſt. Nat.

CROWFOOT. Buttercup. Goldilocks. Bloſſoms yellow. Common in moiſt paſtures and fields. June—July.

The whole plant is acrid. The bloſſoms cure warts and corns.

CALTHA.

CALTHA. Linn. Gen. Plant. 623.

MEADOW-BOUTS. Cowslips. Marsh Marigold. Stems branched. Leaves kidney-shaped. Blossoms yellow. In brooks and watery places. April—May.

Many people esteem it a good pot-herb. Dr. *Withering* says, the flowers gathered, and preserved in salted vinegar, are a good substitute for capers. The juice of the flowers boiled, with the addition of alum, stains paper yellow. It has been supposed, that the remarkable yellowness of butter in the spring, is caused by this plant: but *Boerhaave* says, if cows eat it, it will occasion such inflammation, that they generally die.

DIDYNAMIA.

GYMNOSPERMIA.

TEUCRIUM. Linn. Gen. Plant. 625.

Teucrium foliis ovatis inæqualiter serratis, racemis terminalibus. Syst. Nat.

GERMANDER. Wood Sage. Blossoms white, tinged with red. Near *Dummer* Academy. Not common. July.

NEPETA. Linn. Gen. Plant. 629.

Nepeta floribus spicatis: verticillis subpedicellatis, foliis petiolatis cordatis dentato-serratis. Syst. Nat.

CATMINT. Catnip. Blossoms pale purple, or blue. About barns and fields. July.

An infusion of the plant, especially of the blossoms, is grateful to the stomach, and a mild carminative, but of no great efficacy. Dr. *Withering* says, an infusion of it is deemed a specific in chlorotic cases. It is much used by the country people here in the same cases. Cats are remarkably fond of this plant. Mr. *Miller* says, they eat it until it produces a kind of drunkenness, and then tear it to pieces with their claws.

BETONICA. Linn. Gen. Plant. 631.

Betonica ſpica interrupta, corollaram lacinia labii intermedia emerginata? Syſt. Nat.

HEAD BETONY. The middle ſegment of the lower lip of the bloſſom is toothed. Bloſſoms purple. Woods and fields. July—Auguſt.

Dr. *Withering* ſays, the freſh leaves intoxicate, and the dry leaves excite ſneezing;—that it is ſmoked as tobacco; and that the roots provoke vomiting.

MENTHA. Linn. Gen. Plant. 633.

Mentha floribus ſpicatis, foliis oblongis ſerratis.

HORSE MINT. Bloſſoms blue. By brooks, and in wet meadows. July.

Mentha ſpicis ſolitaris interruptis, foliis lanceolatis ſerratis ſeſſilibus. Syſt. Nat.

SPEAR MINT. Bloſſoms purpliſh red. In moiſt ground. Auguſt.

It has a more agreeable flavour than the Horſe Mint, and is preferred for culinary and medical purpoſes. The juice of the leaves, boiled up with ſugar, is formed into tablets. The leaves make an agreeable conſerve. The diſtilled waters, both ſimple and ſpiritous, are generally eſteemed pleaſant. The eſſential oil and diſtilled waters are conſidered as carminative. They are given with ſucceſs for removing ſickneſs at the ſtomach.

Mentha floribus capitatis, foliis ovatis ſerratis petiolatis, ſtaminibus corolla longioribus. Syſt. Nat.

WATER MINT. Bloſſoms pale red. By brooks and rivers. Auguſt.

Mentha floribus verticillatis, foliis ovatis obtusis suberenatis caulebus subteretibus repentibus. Syst. Nat.

PENNYROYAL. Stamina pale purple. In pastures and fields. July—September.

The expressed juice, with sugar, is given in the hooping cough. An infusion of the plant and the distilled water are antispasmodic, and are prescribed in hysterical cases.

GLECOMA. Linn. Gen. Plant. 634.

Glecoma foliis reniformibus crenatis. Syst. Nat.

GROUND IVY. *Gill-go-over-the-Ground. Robin-run-away.* A decoction of the leaves is esteemed by the common people a remedy for the jaundice. Dr. *Withering* says, the leaves are thrown into the vat with ale, to clarify it, and give it a flavour: and that ale thus prepared, is often drank as an antiscorbutic. The expressed juice mixed with wine, and applied morning and evening, it is said, will destroy white specks upon horses eyes. The plant is also said to be hurtful to horses, if they eat it in large quantities.

GALEOPSIS. Linn. Gen. Plant. 637.

Galeopsis internodiis caulinis superne incrassatis, verticillis summis subcontiguis. Syst. Nat.

ALLHEAL. *Hemp-leaved Dead-Nettle.* Blossoms purple. By the road side. *Gloucester.* August.

STACHYS. Linn. Gen. Plant. 638.

Stachys verticillis sexfloris, foliis cordatis petiolatis. Syst. Nat.

CLOWNHEAL. *Hedge Nettle.* Blossoms purple, spotted with white. By fences and amongst bushes. July—August.

It has a fœtid smell, and toads are thought to be fond of living under its shade. It will dye yellow.

MARRUBIUM.

MARRUBIUM. Linn. Gen. Plant. 640.

Marrubium dentibus calycinis ſetaceis uncinatis. Syſt. Nat.

HOREHOUND. Bloſſoms white. By road ſides, and among rubbiſh. July.

Dr. *Withering* obſerves, that it was a favourite medicine with the ancients in obſtructions of the viſcera.—In large doſes it looſens the belly. He ſays, that it is the principal ingredient in the Negro *Cæſar's* remedy for vegetable poiſons.—That a young man, who had occaſion to take mercurial medicine, was thrown into a ſalivation, which continued for more than a year. Every method that was tried to remove it, rather increaſed the complaint. At length *Linnæus* preſcribed an infuſion of this plant, and the patient got well in a ſhort time.

LEONURUS. Linn. Gen. Plant. 641.

Leonurus foliis caulinis lanceolatis trilobis. Syſt. Nat.

MOTHERWORT. Bloſſoms purpliſh. Among rubbiſh. July —Auguſt.

Leonurus foliis ovatis lanceolatiſque ſerratis, calycibus ſeſſilibus ſpinoſis. Syſt. Nat.

MARRUBY. Lion's Tail. Bloſſoms rediſh. By fences in moiſt land. Not common. July.

ORIGANUM. Linn. Gen. Plant. 645.

Origanum ſpicis ſubrotundis paniculatis conglomeratis, bracteis calyce longioribus ovatis. Syſt. Nat.

WILD MARJORAM. Bloſſoms purple. Amongſt brambles by fences. July.

It is warm and aromatic. Dr. *Withering* ſays, the eſſential oil is ſo acrid that it may be conſidered as a cauſtic, and is much uſed with that intention by farriers. A little cotton wool moiſtened

ened with it, and put into the hollow of an aching tooth, frequently relieves the pain. The dried leaves make an exceedingly grateful tea. The tops of the plant dye purple.

DRACOCEPHALUM. Linn. Gen. Plant. 648.

Dracocephalum floribus ſpicatis, foliis lanceolatis ſerratis. Syſt. Nat.

DRAGON's HEAD. The middle ſegment of the *lower lip* the largeſt ; intire. Bloſſoms variegated with red and white. By ſtone walls in *Dedham*. July.

TRICHOSTEMA? Linn. Gen. Plant. 652.

Trichoſtema ſtaminibus longiſſimis exertis. Syſt. Nat.

WILD LAVENDER. Great Pennyroyal. The *upper lip* divided into two erect ſegments ; compreſſed. The lateral ſegments of the *lower lip* erect ; nearly ſimilar to the ſegments of the upper lip ; middle ſegment larger ; club-ſhaped ; convex ; reflected. *Stigma* bifid ; reflected. Bloſſoms ſolitary ; terminating ; purple. In old fields. Auguſt—September.

SCUTELLARIA. Linn. Gen. Plant. 653.

Scutellaria foliis ſeſſilibus ovatis : inferioribus obſolete ſerratis ; ſuperioribus integerrimis. Syſt. Nat.

HOODWORT. Bloſſoms blue. By fences in *Sandwich*. Aug.

Scutellaria foliis cordato-oblongis acuminatis ſerratis, ſpicis ſubnudis. Syſt. Nat.

TALL HOODWORT. Bloſſoms pale blue. In open wood land in *Weymouth*. Auguſt.

ANGIOSPERMIA.

EUPHRASIA. Linn. Gen. Plant. 659.

Euphraſia foliis linearibus ſerratis : ſuperioribus integerrimis. Syſt. Nat.

EYEBRIGHT.

EYEBRIGHT. Mouthwort. Bloſſoms blue. Amongſt low buſhes. July.

It has been in repute for recovering impared eye-ſight.

MELAMPYRUM. Linn. Gen. Plant.

Melampyrum corollis hiantibus. Syſt. Nat.

COW-WHEAT. Bloſſoms yellowiſh white. In woods. June.

CHELONE. Linn. Gen. Plant. 666.

Chelone foliis lanceolatis ſerratis : ſummis oppoſitis. Syſt. Nat.

CHELONE. Fiſh-head. Snake-head. Bloſſoms in ſpikes; white. Common by fences and amongſt buſhes in moiſt land. Auguſt.

ANTIRRHINUM. Linn. Gen. Plant. 663.

Antirrhinum foliis lanceolatis obtuſis alternis, caule ramoſiſſimo diffuſo. Syſt. Nat.

TOAD-FLAX. Bloſſoms purple. In fields and road ſides. June—Auguſt.

Antirrhinum foliis linearibus alternis, corollis hiantibus : labio inferiore explanato. Syſt. Nat.

SNAP-DRAGON. Fluellin. Bloſſoms yellow, with a mixture of ſcarlet. Common by road ſides in *Lynn* and *Cambridge*. June—July.

The ſeed of a ſpecies of the Antirrhinum, nearly reſembling this plant, and not at all ſuperior in beauty, is imported by our ſeed-ſellers, and is common in curious flower-gardens.

SCROPHULARIA. Linn. Gen. Plant. 674.

Scrophularia foliis cordatis ſerratis acutis baſi rotundatis, caule obtuſangulo. Syſt. Nat.

FIGWORT. Bloſſoms purpliſh, with a ſmall ſegment, reſembling a lip, in their mouths. By fences in wet land. Aug.

The

The plant has a rank ſmell and bitter taſte. It is ſaid, that ſwine that have the ſcab are cured by waſhing them with a decoction of the leaves.

DIGITATIS. Linn. Gen. Plant. 676.

Digitatis calycinis foliolis ovatis acutis, corollis obtuſis: labia ſuperiore integro. Syſt. Nat.

FOX-GLOVE. Hornwort. Bloſſoms red. In moiſt land. Aug.

This is another plant which has been miſtaken for *Paul's Betony*, a ſpecies of the *Veronica*.

BIGNONIA. Linn. Gen. Plant. 677.

TRUMPET-FLOWER. Yellow Jaſmine. Stems round; erect. Leaves lanceolate; oppoſite; irregularly ſerrated. Bloſſoms ſolitary; on ſhort flower-ſtalks riſing from the *axillæ* of the leaves; yellow. On the borders of fields, and in open woods. July.

This plant has alſo been called *Paul's Betony.*

WOOD BETONY. The *calix* a perianthium of one leaf; tubular. Border entire; ſloped. *Corolla* one petal; gaping. Tube twice the length of the calix. Upper lip helmet-ſhaped, with two awns. Lower lip reflected; three concave ſegments, the middle one ſmaller. *Stamina* four filiform filaments, (two a little ſhorter than the other two) concealed by the upper lip. *Antheræ* cloven. *Germen* ovate; compreſſed. *Stile* filiform; longer than the ſtamina. *Stigma* obtuſe. *Capſule* ovate; acuminated; compreſſed; with two cells and two valves. Seeds ovate; ſeveral.

Stems erect. Leaves lanceolate; deeply divided in a pinnated form; the diviſions ſerrated. Bloſſoms in ſpikes; yellow. Common in rich wood land. June.

MIMULUS. Linn. Gen. Plant. 701.

MAIDENWORT. Stems angular; branched. Leaves lanceolate; ſlightly ſerrated; oppoſite; half embracing the ſtalk. Bloſſoms ſolitary; on long flower-ſtalks riſing from the *axillæ* of the leaves; blue. By ſences in moiſt land. Auguſt.

TETRADYNAMIA.

SILICULOSÆ.

MYAGRUM. Linn. Gen. Plant. 713.

Myagrum ſiliculis ovatis pedunculatis polyſpermis. Syſt. Nat.

CAMLINE. Bloſſoms yellow. In fields amongſt flax. June.

THLASPI. Linn. Gen. Plant. 719.

Thlaſpi ſiliculis obcordatis, foliis radicalibus pinnatifidis. Syſt. Nat.

MITHRIDATE. Shepherd's Purſe. Shepherd's Pouch. Bloſſoms white. In corn fields, and about barns. April—June.

COCHLEARIA. Linn. Gen. Plant. 720.

Cochlearia foliis radicalibus ſubrotundis, caulinis oblongis, ſubſinuatis. Syſt. Nat.

SCURVY-GRASS. Bloſſoms white. On high land. Not common in a wild ſtate, but is frequently cultivated in gardens. May—June.

It is acrimonious; and the acrimony is ſaid to reſide in a very ſubtile eſſential oil. It is frequently eaten by country people as a ſallad. Writers on ſea-voyages give high encomiums on the Scurvygraſs for its antiſcorbutic virtues. Dr. *Withering* ſays; it is a powerful remedy in the pituitous aſthma, and in what *Sydenham* calls the ſcorbutic rheumatiſm. A diſtilled water and a conſerve is prepared from the leaves. The juice is preſcribed along with that of oranges, by the name of antiſcorbutic juices.

Cochlearia

Cochlearia foliis radicalibus lanceolatis integerrimis, caulinis subsinuatis. Syst. Nat.

SEA SCURVYGRASS. The leaves are fleshy. Blossoms white. On the sea shore and in marshes. May—June.

This is more acrimonious than the former species. It has a pretty full taste of sea salt, as well as the volatile alkali.

Cochlearia foliis lanceolatis amplexicaulibus dentatis. Syst. Nat.

HORSE-RADISH. Blossoms white. In rich soil in moist land. Not common in an uncultivated state. June—July.

It is so rarely found where it has not been cultivated, that it may possibly be doubted whether it be indigenous. The scraped roots are much used at tables as a condiment, and for many culinary purposes. It has been found a powerful stimulant in paralytic cases, and is useful as a diuretic in dropsies. A distilled water is prepared from it. A strong infusion is emetic.

SILIQUOSA.

CARDAMINE. Linn. Gen. Plant. 727.

Cardamine foliis pinnatis extipulatis, foliolis lanceolatis obtusis, floribus corollatis. Syst. Nat.

LADYSMOCK. Blossoms white. Near small brooks. Not common. May—June.

Cardamine foliis pinnatis: foliolis lanceolatis basi unidentatis. Syst. Nat.

IMPATIENT. Impatient Ladysmock. Blossoms yellowish white. By springs in mountainous land. Very rare. May.

SISYMBRIUM. Linn. Gen. Plant. 728.

Sisymbrium siliquis declinatis, foliis pinnatis: foliolis subcordatis. Syst. Nat.

WATERCRESS. Bloſſoms white. In ſprings and running brooks of water. May.

It is an early and wholeſome ſpring ſallad, and is uſed as a pot-herb. Dr. *Withering* ſays, it is an excellent antiſcorbutic and ſtomachic, with leſs acrimony than the ſcurvygraſs. It is an ingredient in the antiſcorbutic juices.

SINAPIS. Linn. Gen. Plant.

Sinapis ſiliquis glabris tetragonis. Syſt. Nat.

BLACK MUSTARD. Bloſſoms pale yellow. Common about barns. June.

The imported muſtard, ſo common at tables, and which is generally preferred to our own, is the pulverized ſeed of this ſpecies ;—the difference conſiſts only in the preparation of the powder. The ſeeds unbruiſed are frequently given in palſies and chronic rheumatiſms, and are found beneficial. They may be taken in the quantity of a table-ſpoon full, or more, and will gently relax the bowels. Rheumatic pains in the ſtomach are often relieved by taking them in brandy. The powdered ſeeds, with crumbs of bread and vinegar, are made into cataplaſms, and applied to the ſoles of the feet in fevers, when ſtimulants are neceſſary. They are alſo topically applied in fixed rheumatic and ſciatic pains. Dr. *Withering* ſays, wherever we want a ſtrong ſtimulus, that acts upon the nervous ſyſtem without exciting much heat, we know none preferable to the muſtard ſeed. An infuſion of the ſeed, given in large quantities, vomits ; but in ſmaller doſes, operates as an aperient and diuretic. Muſtard whey, with wine, is uſed as a drink in fevers. Its acrimony is ſaid to conſiſt in an eſſential oil.

RAPHANUS. Linn. Gen. Plant. 736.

Raphanus ſiliquis teretibus articulatis lævibus unilocularibus. Syſt. Nat.

CHARLOCK.

CHARLOCK. Bloſſoms white or yellow. Common amongſt rye, barley and flax. June—Auguſt.

It is often very injurious to grain; and when it has once got into the ground it is extremely difficult to extirpate. The ſeeds will remain in the ground many years, in a vegetive ſtate, after it is ſwarded over with graſs, and will grow when the ground is again plowed up. Dr. *Withering* ſays, in wet ſeaſons it grows in great quantity amongſt the barley in *Sweden*; and the common people, who eat barley bread, are afflicted with very violent convulſive complaints in thoſe provinces, and in thoſe ſeaſons wherein this plant abounds.

MONADELPHIA.

DECANDRIA.

GERANIUM. Linn. Gen. Plant. 746.

Geranium pedunculis ſubtrifloris, foliis cordatis crenato-inciſis ſubvilloſis, caulibus procumbentibus. Syſt. Nat.

SEA CRANESBILL. Bloſſoms pale red. In marſhes and on the ſea ſhore. June—July.

Geranium pedunculis bifloris, calycibus inflatis, piſtillo longiſſimo. Syſt. Nat.

COMMON CRANESBILL. Bloſſoms purple. By ſtone walls and borders of fields. May—July.

The root is aſtringent, and frequently uſed in gargles for cankerous ſores in the mouth and throat.

Geranium pedunculis bifloris, calycibus piloſis decemangulatis. Syſt. Nat.

MOUNTAIN CRANESBILL. Herb-Robert. Stockbill. Bloſſoms pale red. Amongſt rocks in high land. June—July.

It is conſiderably aſtringent, and ſmells ſomewhat like muſk. A decoction of the plant has been known to give relief in cal-

culous

culous cases. It is given to cattle when they make bloody water.

POLYANDRIA.

ALTHÆA. Linn. Gen. Plant. 749.

Althæa foliis simplicibus tomentosis. Syst. Nat.

MARSH-MALLOW. Blossoms purplish white. In marshes on *Martha's Vineyard.* August.

It is common in gardens, where it is cultivated for its medical virtues. The whole plant is mucilaginous, but the mucilage abounds most in the roots. It is much used in cataplasms and fomentations as an emollient. An infusion, or decoction, is commonly ordered in all cases which require mild mucilaginous substances.

MALVA. Linn. Gen. Plant. 751.

Malva caule repente, foliis cordato-orbiculatis obsolete quinquelobatis. Syst. Nat.

MALLOW. Blossoms white, tinged with purple. Common about barns. June—September.

DIADELPHIA.

OCTANDRIA.

POLYGALA. Linn. Gen. Plant. 761.

Polygala floribus imberbibus oblongo-capitatis, caule erecto herbaceo simplicissimo, foliis lanceolatis acutis. Syst. Nat.

MILKWORT. Blossoms red and yellow. Common in moist fields. August—September.

This plant is generally called *Low Centaury,* and has, probably, been mistaken for a species of the *Gentiana.*

Polygala.

LONG-SPIKED MILKWORT. Stems erect; branched. Leaves lanceolate. Blossoms in long terminating spikes; pale red. In moist land. Not common. August.

DECANDRIA.

DECANDRIA.

GENISTA. Linn. Gen. Plant. 766.

Geniſta foliis lanceolatis glabris, ramis ſtriatis teretibus erectis. Syſt. Nat.

GREENWOOD. Dyer's Weed. Wood Waxen. Bloſſoms yellow. In paſtures between *New-Mills* and *Salem.* June.

The bloſſoms afford a yellow colour. The powdered ſeeds operate as a mild purgative. A decoction of the plant is diuretic.

ÆSCHYNOMENE. Linn. Gen. Plant. 769.

Æſchynomene caule hiſpido, leguminum articulis ſemicordatis, bracteis cordatis ciliatis, ſtipulis utrinque lanceolatis. Syſt. Nat.

TOOTH-PODDED BEAN. Bloſſoms pale red. On the borders of fields. Auguſt.

LUPINUS. Linn. Gen. Plant. 774.

Lupinus calycibus alternis appendiculatis: labio ſuperiore bipartito, inferiore integro. Syſt. Nat.

LUPINE. Bloſſoms blue. In corn fields, in the ſtate of *Connecticut.* June—Auguſt.

ROBINIA. Linn. Gen. Plant. 775.

Robinia pedunculis ſubdiviſis, foliis pinnatis, floribus foliolo majoribus. Syſt. Nat.

LOCUST-TREE. Bloſſoms white. In the woods in the ſouthern ſtates—only by cultivation here. June.

The wood, when green, is of a ſoft texture, but becomes very hard when it is thoroughly dry. It is as durable as the beſt white oak, and eſteemed preferable for carriage axletrees, trunnels for ſhips, and for many other mechanic purpoſes. It makes excellent fuel, and its ſhade is leſs injurious to graſs than that of moſt other trees. It may be propagated with great eaſe and to very advantageous purpoſes.

PISUM.

PISUM. Linn. Gen. Plant. 779.

Pisum petiolis supra planiusculis, caule angulato, stipulis sagittatis, pedunculis multifloris. Syst. Nat.

SEA PEA. Blossoms pale red and purple. On sandy beaches near the sea. July—August. They are esculent.

Pisum petiolis decurrentibus membranaceis diphyllis, pedunculis unifloris. Syst. Nat.

PIED PEA. Blossoms red, purple and white. In rich moist land. June—July.

OROBUS. Linn. Gen. Plant. 780.

Orobus pinnatis ovatis stipulis semisagittatis integerrimis, caule simplici. Syst. Nat.

PEASELING. Blossoms purple. Near *New-Mills* in *Danvers.* June—July.

Oribus foliis pinnatis lanceolatis, stipulis semisagittatis integerrimis, caule simplici. Syst. Nat.

WOOD PEAS. *Heath Peas.* Blossoms red and yellow. In shrub-oak and pine land. July.

It is said, that the roots, when boiled, are savory and nutritious—Ground into powder, they may be made into bread.—That they are held in high esteem by the Highlanders in *Scotland,* who chew them as people do tobacco, and find that they prevent the uneasy sensation of hunger. They imagine, that they promote expectoration, and are very efficacious in curing disorders of the lungs. They know how to prepare an intoxicating liquor from them.

Orobus caulibus decumbentibus hirsutis ramosis. Syst. Nat.

WOOD PEASELING. Blossoms redish white. Borders of wood land. July.

LATHYRUS.

LATHYRUS. Linn. Gen. Plant. 781.

Lathyrus pedunculis multifloris, cirrhis diphillis : foliolis ovalibus, internodiis nudis. Syſt. Nat.

VETCHLING. Bloſſoms purple. Sandy beaches. July.

Lathyrus pedunculis multifloris, cirrhis polyphyllis, ſtipulis ovatis : baſi acutis. Syſt. Nat.

CHICKLING PEAS. Bloſſoms purple and white. In *Salem*, near the ſea. July.

VICIA. Linn. Gen. Plant. 782.

Vicia leguminibus pedicellatis ſubquaternis erectis, foliolis ovatis integerrimis : exterioribus decreſcentibus. Syſt. Nat.

VETCH. Bloſſoms purple. Borders of fields. July.

INDIGOFERA. Linn. Gen. Plant. 794.

Indigofera leguminibus horizontalibus teretibus, foliis pinnatis ternatiſque ? Syſt. Nat.

INDIGOWEED. Bloſſoms yellow. Common in paſtures and woods. July—Auguſt.

A durable pale blue may be obtained from the leaves and ſmall branches. Fomentations of the plant, it is ſaid, will abate the ſwelling, and counteract the poiſon in the bite of rattle-ſnakes.

TRIFOLIUM. Linn. Gen. Plant. 802.

The indigenous ſpecies of this genus are too numerous to admit of a particular deſcription. Several of them are generally known, viz. The *Melilot Clover.* The *Creeping Clover.* The *White Honeyſuckle.* The *Red Honeyſuckle.* The *Yellow Clover.* The *Woolly-headed Clover,* or *Chuckle-head.* The *Tall Trefoil.*

MEDICAGO. Linn. Gen. Plant. 805.

GROUND NUT. The germen is rolled inwards, but the pod becomes nearly ſtrait, containing ſeveral kidney-ſhaped ſeeds.

Stems twining. Bloſſoms in cluſters, placed in the *axillæ* of the leaves; red or red and white. Common in loamy wood land. July.

The roots are roundiſh and eſculent, and were eaten by the Indians.

POLYADELPHIA.

POLYANDRIA.

HYPERICUM. Linn. Gen. Plant. 808.

Hypericum floribus trigynis: petatis calyce ſublongioribus, foliis ovali-oblongis obtuſis ſemiamplexicaulibus, caule tereti. Syſt. Nat.

TUTSAN. All Saint's Wort. Bloſſoms pale red. Moiſt land. Auguſt.

Hypericum floribus trigynis, caule quadrato herbaceo. Syſt. Nat.

St. PETER's WORT. Bloſſoms yellow. Moiſt meadows. July.

Hypericum floribus trigynis, caule ancipiti, foliis obtuſis pellucido-punctatis. Syſt. Nat.

St. JOHN's WORT. Bloſſoms yellow. In fields. July—Aug. The ſmall dots upon the leaves, which appear like ſo many perforations, are ſaid to contain an eſſential oil. The leaves are given to deſtroy worms. The flowers tinge ſpirits and oil of a fine purple colour.

SYNGENESIA.

POLYGAMIA ÆQUALIS.

SONCHUS. Linn. Gen. Plant. 813.

Sonchus pedunculis hiſpidis, floribus racemoſis, foliis lyrato-haſtatis. Syſt. Nat.

SOWTHISTLE. Bloſſoms purple. On ditch banks. Auguſt—September.

LACTUCA.

LACTUCA. Linn. Gen. Plant. 814.

Lactuca foliis laciniato-ensiformibus dentatis inermibus. Syst. Nat.

WILD LETTUCE. Milkweed. Bloſſoms yellow. About barns and fields. Auguſt—September.

The milky juice is ſaid to poſſeſs the properties of opium. It may be collected in ſhells, dried by a gentle heat, and made into pills.

PRENANTHES. Linn. Gen. Plant. 816.

Prenanthes floſculis plurimis, floribus nutantibus ſubumbellatis, foliis haſtato-angulatis. Syſt. Nat.

IVYLEAF. Ivy-leafed Wild Lettuce. Snake-weed. Bloſſoms white. By ſtone walls in rich moiſt land. Auguſt.

LEONTODON. Linn. Gen. Plant. 817.

Leontodon calyce inferne reflexo. Syſt. Nat.

DANDELION. Bloſſoms yellow. Graſs land. May—Sept.

The leaves, early in the ſpring, are much eſteemed as a pot-herb and in ſallads. It is ſometimes tranſplanted into gardens, and blanched like endive. The *French* eat the roots and leaves with bread and butter. It is in a conſiderable degree diuretic. *Boerhaave* had a great opinion of the utility of this and other lacteſcent plants in obſtructions of the viſcera. The expreſſed juice is ſaid to have been given, to the quantity of four ounces, three or four times a day.

HIERACIUM. Linn. Gen. Plant. 629.

Hieracium caule multifloro, foliis lyratis glabris, calyce pedunculiſque hiſpidis. Syſt. Nat.

HAWKWEED. Bloſſoms yellow. About barns and rubbiſh. Auguſt.

Hieracium caule erecto multifloro, foliis lanceolatis dentatis, pedunculis tomentosis. Syst. Nat.

RATTLE-SNAKE PLANTAIN. Poor Robin's Plantain. Blossoms pale yellow. The radical leaves are of a reddish colour, and spread on the ground like plantain. In woods. June—Aug. It is said to have been considered by the Indians as an infallible cure for the bite of rattle-snakes. They chewed the leaves in the mouth, and, after swallowing part of the juice, applied them to the wound. This is, probably, the plant which *Carver* says the Indians were convinced was such a powerful antidote, that for a trifling bribe of spiritous liquors, they would at any time permit a rattle-snake to drive his fangs into their flesh.

CREPIS. Linn. Gen. Plant. 819.

Crepis involucris calyce longioribus : squamis setaceis sparsis. Syst. Nat.

BLUE SUCCORY. Blossoms blue. Fields in *Cambridge.* July. It is said to be a good stamachic.

Crepis involucris ovatis concavis obtusis patentibus. Syst. Nat.

YELLOW SUCCORY. Blossoms yellow. Wood land. August.

ARCTIUM. Linn. Gen. Plant. 830.

Arctium foliis cordatis inermibus petiolatis. Syst. Nat.

BURDOCK. Blossoms purple. About barns. July—Aug. The young stems boiled, divested of the bark, are esteemed little inferior to asparagus. They are also eaten raw with oil and vinegar. Dr. *Withering* says, a decoction of the roots is esteemed, by some very sensible physicians, as equal, if not superior, to that of sarsaparilla.

SERRATULA. Linn. Gen. Plant. 831.

Serratula foliis lanceolatis, ſquamis calycinis apice membranaceis obtuſis patulis coloratis, floribus terminalibus. Syſt. Nat.

DEVIL'S BIT. The root appears as if bitten off. Bloſſoms purple. Old fields. Auguſt—September.

In *England*, a plant of the fourth claſs is called *Devil's Bit*, the *Scabioſa ſucciſa*. Linn. *Morſus diaboli vulgaris, flore purpureo.* Park. An infuſion of the roots of this plant, in a cloſe veſſel, has been found very ſerviceable in ſcrophulus complaints.

CARDUUS. Linn. Gen. Plant. 832.

Carduus foliis ſinnatis decurrentibus: marginis ſpinoſis, calycibus pedunculatis ſolitariis erectis villoſis. Syſt. Nat.

WELTED THISTLE. Bloſſoms pale red. Road ſides. July.

Carduus foliis ſeſſilibus bifariam pinnatifidis: laciniis alternis erectis, erectis, calycibus globoſis villoſis. Syſt. Nat.

STAR THISTLE. *Friar's Crown.* Bloſſoms purple. In paſtures. July—Auguſt.

Carduus foliis pinnatifidis ſpinoſis ſeſſilibus, caule inermi, floribus ſolitariis. Syſt. Nat.

LADIES THISTLE. Bloſſoms purple. Road ſides. July.

Carduus foliis lanceolatis dentatis amplexicaulibus: ſpinulis inæqualibus ciliatis, caule inermi. Syſt. Nat.

YELLOW THISTLE. Bloſſoms yellow. In *Chelſea*. June.

The flowers of thiſtles have the property of rennet in curdling milk.

CARLINA. Linn. Gen. Plant. 836.

Carlina caule multifloro corymboſo, floribus terminalibus. Syſt. Nat.

FIRE-WEED. Bloſſoms white. It abounds in new plantations where the ground has been burnt over. Aug.

BIDENS. Linn. Gen. Plant. 840.

Bidens foliis pinnatis ſerratis glabris, ſeminibus erectis, calycibus frondoſis, caule lævi. Syſt. Nat.

HARVEST-LICE. Cuckold. Bloſſoms yellow. In corn fields. September.

EUPATORIUM. Linn. Gen. Plant. 842.

Eupatoriun foliis quaternis ſcabris lanceolato-ovatis inæqualiter ſerratis petiolatis rugoſis. Syſt. Nat.

LIVER-HEMP. Honeſty. Hemp Agrimony. Bloſſoms pale red. In moiſt land, by brooks and rivers. July—Auguſt.

Dr. *Withering* ſays, an infuſion of an handful of it, vomits and purges ſmartly. An ounce of the root, in decoction, is a full doſe. In ſmaller doſes the *Dutch* peaſants take it as an alterative and an antiſcorbutic.

Eupatorium foliis connatis tomentoſis. Syſt. Nat.

THOROUGH-WAX. Bloſſoms white. In moiſt land. July—Auguſt.

The *Bupleurum rotundifolium.* Linn. The *Perfoliata vulgaris.* Park. of the fifth claſs, is called *Thorough-wax* in *England.* An infuſion of the leaves is a powerful emetic.

AGERATUM. Linn. Gen. Plant. 843.

Ageratum foliis ovatis crenatis obtuſis, caule glabro. Syſt. Nat.

MEADOW SUNFLOWER. Bloſſoms yellow. In wet meadows. September.

STÆHELINA. Linn. Gen. Plant. 844.

Stæhelina foliis ſubtrigonis, ſquamis calycinis crenatis. Syſt. Nat.

PRICKLY DEVIL's-BIT. Bloſſoms purple. On *Winter-Hill* in *Charleſtown.* July—Auguſt.

POLYGAMIA

POLYGAMIA SUPERFLUA.

TANACETUM. Linn. Gen. Plant. 848.

Tanacetum foliis bipinnatis ſerratis. Syſt. Nat.

TANSEY. Bloſſoms yellow. Paſtures. Auguſt.

The leaves are frequently uſed to give a colour and flavour to pudding. Freſh meat may be preſerved from the attacks of the fleſh-fly, by rubbing it with this plant. It is conſidered as a warm deobſtruent bitter. The *Finlanders* are ſaid to obtain a green dye from it.

ARTEMISIA. Linn. Gen. Plant. 849.

Artemiſia foliis compoſitis multifidis, floribus ſubgloboſis pendulis: receptaculo villoſo. Syſt. Nat.

WORMWOOD. Bloſſoms browniſh white. Road ſides, and amongſt rubbiſh. July—Auguſt.

The leaves and flowers are well known to be bitter, and to reſiſt putrefaction. They are made a principle ingredient in antiſceptic fomentations. The roots are warm and aromatic. The plant affords a conſiderable quantity of eſſential oil, by diſtillation, which is uſed both internally and externally to deſtroy worms. Fomentations, or cataplaſms of the leaves are ſometimes applied to the bellies of children in obſtinate worm caſes. An infuſion of the leaves is ſaid to be a good ſtomachic, and with the addition of fixed alkaline ſalt, a powerful diuretic in dropſical caſes. *Linnæus* has mentioned two caſes, wherein an eſſence, prepared from this plant, and taken for a conſiderable time, prevented the formation of ſtones in the kidneys and bladder—the patients forbearing the uſe of wine and acids. If women, that ſuckle, take an infuſion of this plant, it makes their milk bitter. The leaves put into ſour beer, ſoon deſtroy the aceſcency.

Artemiſia

Artemisia foliis pinnatifidis planis incisis subtus tomentosis, racemis simplicibus, floribus ovatis : radio quinquefloro. Syst. Nat.

MUGWORT. Blossoms purplish. Borders of fields. Aug. Dr. *Withering* says, in some countries it is used as a culinary aromatic. A decoction of it is taken by the common people to cure the ague.

GNAPHALIUM. Linn. Gen. Plant. 850.

Gnaphalium foliis semiamplexicaulibus ensiformibus repandis obtusis utrinque pubescentibus, floribus conglomeratis. Syst. Nat.

CATSFOOT. Woolly Mouse-Ear. Blossoms yellowish white. Road sides. August.

Gnaphalium foliis decurrentibus obtusis mucronatis utrinque tomentosis planis. Syst. Nat.

LIFE-EVERLASTING. Blossoms white. In pastures and fields. September.

NONE-SO-PRETTY. Stems herbaceous ; branched. Leaves ovate ; slightly serrated ; sessile ; alternate. Blossoms in broad topped spikes ; redish purple. Female florets in the circumference, and without petals.

ERIGERON. Linn. Gen. Plant. 855.

Erigeron ramis lateralibus multifloris, calycibus squarrosis. Syst. Nat.

FLEABANE. Florets in the circumference white ; those in the center purple. By fences. August.

Erigeron caule floribusque paniculatis. Syst. Nat.

MEADOW FLEBANE. Florets in the circumference white ; those in the center yellow. Moist land. August—September.

Erigeron pedunculis alternis unifloro. Syst. Nat.

ROSEBETTY. Blossoms in the circumference purple ; those in the center yellow. By fences. August—Sept.

TUSSILAGO.

TUSSILAGO. Linn. Gen. Plant. 856.

Tussilago scapo imbricato unifloro, foliis subcordatis angulatis denticulatis. Syst. Nat.

COLTSFOOT. Blossoms yellow. About barns. April.

Dr. *Withering* says, the leaves are the basis of the *British* herb tobacco.—They are somewhat austre, bitterish, and mucilaginous to the taste. They have been much used in coughs and consumptive complaints. Dr. *Cullen* has found them to do considerable service in scrophulous cases.—He gives a decoction of the dried leaves, and finds it succeed where sea-water has failed.

SENECIO. Linn. Gen. Plant. 857.

Senecio corollis radiantibus, foliis ensiformibus acute serratis subtus subvillosis, caule stricto? Syst. Nat.

GROUNDSEL. Stanchbood. Blossoms in branched particles; white. Borders of corn fields. August—October.

This plant has been found very efficacious in stopping hemorrhages in certain persons, subject to a very singular kind of constitutional bleeding, when other means have failed. If the bleeding be occasioned by the rupture of internal blood-vessels, they drink a strong decoction of the plant: if it be external, they both drink the decoction, and apply to the wound the fresh leaves bruised, or the dried plant in form of a poultice.

ASTER. Linn. Gen. Plant. 858.

Aster foliis linearibus integerrimis, caule paniculato. Syst. Nat.

BUSHY ASTER. Florets in the circumference white, tinged with red; in the center yellow. By fences. September.

Aster foliis linearibus acutis integerrimis, caule corymboso ramosissimo. Syst. Nat.

DWARF ASTER. Florets in the circumference purple; in the center yellow. In hedges. Auguſt.

Aſter foliis lanceolatis integerrimis ſemiamplexicaulibus, floribus confertis terminalibus, pedunculis nudis, caule hiſpido. Syſt. Nat.

NEW-ENGLAND ASTER. Florets in the circumference purple; in the center yellow. Borders of fields. Aug.—Sept.

SOLIDAGO. Linn. Gen. Plant. 859.

Solidago paniculato-corymboſa, racemis recurvatis, floribus adſcendentibus, foliis trinerviis ſubſerratis ſcabris. Syſt. Nat.

ROUGH-LEAVED GOLDENROD. Bloſſoms yellow. Borders of fields. Auguſt.

Solidago paniculato-corymboſa, racemis recurvis, floribus adſcendentibus, foliis enerviis, ſubintegerrimis. Syſt. Nat.

SMOOTH-LEAVED GOLDENROD. Bloſſoms yellow. Borders of fields. Auguſt.

Solidago caule obliquo, pedunculis erectis foliolatis ramoſis, foliis lanceolatis integerrimis. Syſt. Nat.

MARSH GOLDENROD. Bloſſoms yellow. Borders of marſhes. Auguſt.

INULA. Linn. Gen. Plant. 860.

Inula foliis ovatis rugoſis ſubtus tomentoſis, calycum ſquamis ovatis. Syſt. Nat.

ELECAMPANE. Bloſſoms yellow. Road ſides. Auguſt.

Dr. *Withering* ſays, the root is eſteemed a good pectoral. Dr. *Hill* ſays, he knows, from his own experience, that an infuſion of the freſh root, ſweetened with honey, is an excellent medicine in the hooping cough.

CHRYSANTHEMUM.

CHRYSANTHEMUM. Linn. Gen. Plant. 866.

Chryſanthemum foliis amplexicaulibus oblongis : ſuperne ſerratis ; inferne dentatis. Syſt. Nat.

WHITE WEED. Goldens. Daiſie. Florets in the circumference white ; in the center yellow. In fields and paſtures. May—June. The young leaves may be eaten as ſallad. It is very injurious to graſs land.

ANTHEMIS. Linn. Gen. Plant. 876.

Anthemis receptaculis conicis : paleis ſetaceis, ſeminibus nudis. Syſt. Nat.

MAY-WEED. Florets in the circumference white ; in the center yellow. Road ſides. June—Auguſt.

It is ſaid to be grateful to toads, and very ungrateful to bees.

ACHILLEA. Linn. Gen. Plant. 871.

Achillea foliis bipinnatis nudis : laciniis linearibus dentatis. Syſt. Nat.

YARROW. Bloſſoms white. In dry paſtures. June—Aug.

Dr. *Withering* ſays, the flowers yield an eſſential oil :—that the leaves are celebrated by the *materia medica* writers for a variety of purpoſes, but they are little attended to at preſent.

POLYGAMIA FRUSTRANEA.

HELIANTHUS. Linn. Gen. Plant. 877.

Helianthus foliis oppoſitis ſeſſilibus ovato-oblongis trinerviis panicula dichotoma. Syſt. Nat.

ROUGH-LEAVED SUNFLOWER. Bloſſoms yellow. Borders of fields. Auguſt—September.

It is, in a conſiderable degree, aſtringent. A decoction of the plant is much eſteemed by the common people in diarrhœas.

RUDBECKIA ? Linn. Gen. Plant. 878.

AMERICAN GLOBE AMARANTHUS. The leaves lanceolate ; alternate ; ſeſſile ; downy. Stems woolly. Bloſſoms globular.

Barren florets numerous; entire; white.—Fertile florets ſmall; yellow. They ſtand in a broad-topped ſpike. The bloſſoms are durable after they are taken off. It makes a pretty appearance in flower borders. In high, rich paſtures. Aug.—Oct.

COREOPSIS. Linn. Gen. Plant. 879.

Coreopſis foliis pinnatis ſerratis, radio florum diverſicolore. Syſt. Nat.

MEADOW CUCKOLD. Bloſſoms yellow, red, and white. In wet meadows. Auguſt.

MONOGAMIA.

LOBELIA. Linn. Gen. Plant. 897.

Lobelia caule erecto, foliis lanceolato-linearibus obtuſiuſculis alternis integerrimis, racemo terminali. Syſt. Nat.

SPINET. Bloſſoms blue. In moiſt graſs land. June—July.

Lobelia caule erecto, foliis lanceolatis ſerratis ſpica terminali. Syſt. Nat.

AMERICAN PRIDE. Bloſſoms ſcarlet. Borders of brooks and rivers. Auguſt.

Lobelia.

EMETICWEED. The leaves oblong; ſlightly ſerrated; ſeſſile; alternate; on the upper ſurface numerous tubercles. Stems branched. Bloſſoms ſolitary; in a kind of ſpike; pale blue. Common in dry fields. Auguſt.

The leaves chewed in the mouth are, at firſt, inſipid, but ſoon become pungent, occaſioning a copious diſcharge of ſaliva. If they are held in the mouth for ſome time, they produce giddineſs and pain in the head, with a trembling agitation of the whole body: at length they bring an extreme nauſea and vomiting. The taſte reſembles that of tarter emetic. A plant

poſſeſſed

possessed of such active properties, notwithstanding the violent effects from chewing the leaves, may possibly become a valuable medicine.

VIOLA. Linn. Gen. Plant. 898.

Viola acaulis, foliis pinnatifidis. Syst. Nat.

MOUNTAIN VIOLET. Blossoms variegated. On the hills in *Lynn.* October.

Viola acaulis, foliis reniformibus. Syst. Nat.

MARSH VIOLET. Blossoms pale blue. In moist meadows. April.

Viola acaulis, foliis cordatis, stolonibus reptantibus. Syst. Nat.

SWEET VIOLET. Blossoms deepish purple. In moist warm land. April.

The flowers and the seeds are said to be mild laxatives. The leaves give the blue colour to the sirup of violets, which is changed by an acid to red, and by an alkali to green. It is said, that slips of white paper stained with the petals, and kept from the air and the light, will be changed in the same manner.

Viola caule erecto, foliis cordatis acuminatis. Syst. Nat.

YELLOW VIOLET. Blossoms yellow. In shady places. May.

It is said the Indians applied the bruised leaves to boils and painful swellings, for the purpose of easing the pain and producing suppuration.

IMPATIENS. Linn. Gen. Plant. 899.

Impatiens pedunculis multifloris solitariis foliis ovatis, geniculis caulinis tumentibus. Syst. Nat.

WEATHERCOCK. *Balsamine.* *Touch-me-not.* *Quick-in-the-Hand.* Blossoms yellow. Banks of rivulets. July—Aug.

It

It is generally known here by the name of *Celandine*, and is much celebrated among the common people for curing the jaundice.

GYNANDRIA.

DIANDRIA.

ORCHIS. Linn. Gen. Plant. 900.

Orchis nectarii cornu ſetaceo longitudine germinis : labio tripartito ciliari. Syſt. Nat.

LADY's PLUME. *Female-handed Orchis.* Bloſſoms in large ſpikes; white, or purpliſh, or fleſh-colour'd. In wet meadows. Auguſt.

OPHRYS. Linn. Gen. Plant. 902.

Ophrys bulbis aggregatis oblongis caule ſubfolioſo, floribus ſecundis, nectarii labio indiviſo. Syſt. Nat.

TRIPLE LADY's TRACES. Bloſſoms in a ſpiral ſpike; yellowiſh white. In moiſt land. Auguſt.

ARETHUSA? Linn. Gen. Plant. 905.

Arethuſa radice globoſa, ſcapo vaginato, ſpatha diphyllæ. Syſt. Nat.

RED-WINGED ORCHIS. Bloſſoms red or purple. In moſſy meadows. Auguſt.

CYRRIPEDIUM. Linn. Gen. Plant. 906.

Cyrripedium radicibus fibroſis, foliis ovato-lanceolatis caulinis. Syſt. Nat.

LADY's SLIPPER. The petals red. *Nectarium* fleſh-colour'd, with dark red veins. In moiſt ſhady places. May—June.

Cateſby ſays, the flowers of this plant, which are very ſingular, were in great eſteem with the Indians for decking their hair.

hair. They called it the *Moccasin Flower.* It is easily propagated in gardens by transplanting the roots, which are perennial.

TRIANDRIA.

SISYRINCHIUM. Linn. Gen. Plant. 908.

Sisyrinchium caule foliisque ancipitibus. Syst. Nat.

BLUE-EYED GRASS. Blossoms blue. In grass land. May—June. It makes very pretty edging for borders in gardens.

POLYANDRIA.

ARUM. Linn. Gen. Plant. 915.

Arum acaule, foliis hastato-cordatis acutis : angulis obtusis. Syst. Nat.

CUCKOWPINT. *Dragon-root. Wake-Robin. Lords & Ladies. Spatha* striped with red or black. Berries red.

The fresh root is extremely acrid. The dried root, grated into water, is frequently given as a carminative. It is said the Indians boiled both the shreded roots and berries with their venison. Dr. *Withering* says, the root has been employed in medicine as a stimulant, but when reduced to powder it looses much of its acrimony ; and there is reason to suppose, that the compound powder which takes its name from this plant, owes its virtue chiefly to the other ingredients ;—that there is no doubt but the acrid quality of the plant may be turned to very useful purposes ; but we must first learn how to ascertain its dose. He says, the root, dried and powdered, is used by the *French* to wash their skin with.—It is sold at a high price, under the name of Cypress Powder.—It is undoubtedly a good and an innocent cosmetic.—When the acrimony of the roots is extracted, by boiling or baking, they afford a very mild and wholesome nourishment.—Many nations prepare the only bread they have from plants as acrimonious as this ; first dissipating the

the noxious qualities by the force of heat.—Starch may be made from the roots.

CALLA. Linn. Gen. Plant. 917.

Calla foliis cordatis, spatha plana, spadice undique hermaphrodito. Syst. Nat.

HEART-LEAF FLAG. *Spatha* on the inner side white. Stamina yellow. Berries red. In watery places.

MONOECIA.

MONANDRIA.

ZANNICHELLIA. Linn. Gen. Plant. 920.

ODDITY. Stems hairy; erect. Leaves ovate; slightly serrated; alternate. Blossoms in pairs in the *axillæ* of the leaves. The calix tinged with red. In pastures. September.

ELATERIUM. Linn. Gen. Plant. 1036. 6 Edit.

WILD CUCUMBER. The stems, leaves and blossoms like those of the cucumber. *Hampton* falls, in the state of *New-Hampshire.* August—September.

TETANDRIA.

BETULA. Linn. Gen. Plant. 933.

The limits of this paper will admit of giving only the *English* names of this and the following genera of trees.——The *White Birch.* The *Black Birch.* The *Alder,* or *Owler.*

URTICA. Linn. Gen. Plant. 935.

Urtica foliis oppositis ovalibus. Syst. Nat.

NETTLE. *Stinging Nettle.* The leaves are deeply serrated. The young shoots, early in the spring, are a good pot-herb. A leaf put upon the tongue, and pressed against the roof of the mouth, is said to be efficacious in stopping a bleeding at the nose.

nose. The parts affected in paralytic cases have been recovered by stinging them with this plant. Dr. *Withering* says, the stings are very curious microscopic objects.—They consist of an exceeding fine pointed, tapering, hollow substance, with a perforation at the point, and a bag at the base. When the sting is pressed upon, it readily punctures the skin; and the same pressure forces up an acrimonious fluid from the bag, which instantly squirts into the wound, and produces an effect which almost every one has experienced. The stalks are dressed like flax, for making cloth or paper. The leaves cut fine, and mixed with dough, are very good for young turkeys.

PENTANDRIA.

AMBROSIA. Linn. Gen. Plant. 938.

Ambrosia foliis bipinnatifidis: racemis paniculatis terminalibus glabris. Syst. Nat.

CONOT-WEED. Roman Wormwood. In great plenty on the borders of cultivated fields. September.

It is generally called *Roman Wormwood*, and seems to have been mistaken for the *Artemisia maritima.* Linn. It has somewhat the smell of camphire. It is used in antisceptic fomentations. When it abounds amongst rye or barley, the seeds are thrashed out with the grain, and will give bread, made of it, a bitter and disagreeable taste.

AMARANTHUS. Linn. Gen. Plant. 941.

Amaranthus racemis pentandris compositis erectis foliis oblongo-ovatis. Syst. Nat.

HOG-WEED. White Amaranthus. Amongst rubbish. August.

Amaranthus racemis pentandris compositis patulo-nutantibus, foliis lanceolato-ovatis. Syst. Nat.

BLOODY AMARANTHUS. Love-lies-a-bleeding. Princes Feather. Amongſt rubbiſh. Auguſt.

A decoction of this plant, drank freely, has been found efficacious in uterine hæmorrhages, when other powerful ſtyptics have failed.

POLYANDRIA.

QUERCUS. Linn. Gen. Plant. 949.

The *White Oak.* The *Red Oak.* The *Yellow Oak.* The *Grey Oak.* The *Black Oak.* The *Swamp Oak.* The *Cheſnut Oak.* The *Shrub Oak.*

JUGLANS. Linn. Gen. Plant. 950.

The *White Walnut.* The *Red-hearted Walnut.* The *Oil Nut,* or *Butter Nut.*

FAGUS. Linn. Gen. 951.

The *Larger Cheſnut.* The *Smaller Cheſnut,* with egg-ſhaped nuts. The *Beech.*

CARPINUS. Linn. Gen. Plant. 952.

The *Horn Beam.*

CORYLUS. Linn. Gen. Plant. 953.

The *Round-ſhelled Hazle.* The *Long-ſhelled Hazle.*

LIQUIDAMBAR. Linn. Gen. Plant. 955.

Liquidambar foliis oblongis ſinuatis. Syſt. Nat.

SWEET FERN. A ſmall ſhrub. Common in dry paſtures. July—Auguſt.

MONADELPHIA.

PINUS. Linn. Gen. Plant. 956.

The *White Pine.* The *Yellow Pine.* The *Pitch Pine.* The *Norway Pine.* The *White Cedar.* The *Red Cedar.* The *Fir.* The *Hemlock,* The *Spruce,* The *Taccamahac.*

DIOECIA.

DIOECIA.

DIANDRIA.

SALIX. Linn. Gen. Plant. 976.

The *White Willow*. The *Red Willow*. The *Rose Willow*. The *Dogwood*. The *Osier*.

An account is given, in the Transactions of the Royal Society, (vol. liii. p. 195) by the Rev. Mr. *Stone*, of the great efficacy of white willow bark in curing intermitting fevers. He gathered the bark in summer, when it was full of sap;—dried it by a gentle heat, and gave a dram of it powdered, every four hours betwixt the fits. In a few obstinate cases he mixed it with one fifth part of *Peruvian* bark. Some judicious physicians, here, have made trial of the bark of the white willow, and recommend it as a valuable substitute for the *Peruvian* bark. They have used principally the bark of the roots.

HEXANDRIA.

SMILAX. Linn. Gen. Plant. 992.

Smilax caule inermi tereti, foliis inermibus: caulinis cordatis, rameis ovato-oblongis? Syst. Nat.

BIND-WEED. *Bramble*. Blossoms greenish white. Berries black. In moist hedges. June.

OCTANDRIA.

POPULUS. Linn. Gen. Plant. 996.

The *White Poplar*. The *Trembling Poplar*, or *Aspen Tree*. The *Black Poplar*, commonly called, in the northern states, the *Balm of Gilead*.

POLYANDRIA.

CLIFFORTIA. Linn. Gen. Plant. 1004.

Cliffortia foliis ternatis: intermedio tridentato. Syst. Nat.

THREE-LEAVED CLIFFORTIA. *Snake-weed*. In moist land. May—June.

POLYGAMIA.

MONOECIA.

VERATRUM. Linn. Gen. Plant. 1013.

Veratrum racemo supradecomposito, corollis erectis. Syst. Nat.

WHITE HELEBORE. Poke-root. Indian Poke. Common in wet meadows and swamps. June.

The root is a most drastic cathartic and sternutatory. The fresh roots, beaten up with hog's lard, cures the itch. It is said, the roots are poisonous to swine. Crows may be destroyed by boiling Indian corn in a strong decoction of the fresh roots, and strewing it on the ground where they resort.

ACER. Linn. Gen. Plant. 1023.

The *Great Maple*, or *Sycamore Tree*. The *Rock Maple*. The *Sugar Maple*.

DIOECIA.

FRAXINUS. Linn. Gen. Plant. 1026.

The *White Ash*. The *Red Ash*. The *Black Ash*. The *Prickley Ash*.

PANAX. Linn. Gen. Plant. 1031.

Panax foliis ternis quinatis. Syst. Nat.

GINSENG. Ninsin. It is said to grow plentifully in some parts of this, and in some of the neighbouring states. May—June.

This plant is the famous *panacea* of the *Chinese*, to which they have recourse in all diseases, as the last remedy. The *European* physicians esteem it a good medicine in convulsions, vertigoes, and all nervous complaints, and recommend it as one of the best restoratives known. Its dose is from ten grains to twenty, in powder; and from one dram to two to the pint, in infusions. An infusion of the leaves is drank among the *Chinese* and *Tartars*, by people of distinction, instead of tea; but

it

it is too dear for the common people to uſe. The dried roots and leaves are ſaid to be ſold amongſt them for three times their weight in ſilver. The young roots are preferred to the old. They collect the roots only in the ſpring and fall. They are waſhed in a decoction of millet ſeed, and then ſuſpended over the fumes of the ſame liquor, in a cloſe veſſel, while it is boiling. After this, they dry it for uſe; and when dried, it becomes almoſt tranſparent. The young fibres which are taken off, they boil in water, and make an extract of them, which they uſe in the ſame intention with the root. From the quantity that grows in this country, and the demand for it in the *Eaſt-Indies*, and other parts of the world, we have reaſon to hope it will become a valuable export.

The indigenous plants of the twenty-fourth claſs, whoſe flowers are inconſpicuous, are too numerous to be deſcribed in this paper.

XXV. *A Letter on the Retreat of House-Swallows in Winter; from the Honourable* SAMUEL DEXTER, *Esq; to the Honourable* JAMES BOWDOIN, *Esq; Pres. A. A.*

Dedham, June 3, 1783.

DEAR SIR,

AMONG more important branches of natural history, with which you are converſant, ornithology cannot have eſcaped your notice.

I know it has been a problem among naturaliſts, whether certain ſpecies of birds emigrate in autumn to diſtant countries, and return in the ſpring, or remain with us during the winter, in a torpid ſtate; and that the former opinion has generally prevailed. When, therefore, I acquaint you that I have adopted the latter, with reſpect to the *houſe-ſwallow*, you will juſtly expect that I give you ſubſtantial reaſons for differing from ſo many who have maintained the contrary.

The late Judge *Foſter*, of *Brookfield*, a year or two before his death, aſſured me, that he ſaw a certain pond drained, about the ſeaſon of the year when the ſwallows firſt appear. The buſineſs being effected, and the weather fair and warm, he, with ſeveral others, obſerved a rippling motion in many parts of the emptied hollow; which, on a near inſpection, they found to be occaſioned by a multitude of ſwallows, endeavouring to diſengage themſelves from the mud, which was ſcarcely covered by the ſhallow remains of water.

I ſhall now mention ſome other facts, which render it probable, that this ſort of ſwallows ſink into ponds and rivers, in the fall of the year, and lie there, benumbed and motionleſs, until the return of ſpring.

You

You know, Sir, that my houſe is near a large river. This river is, in many parts, ſhallow, and has a muddy bottom. A former neighbour of mine, a plain, honeſt and ſenſible man, now deceaſed, who lived ſtill nearer to the river, uſed frequently to ſay to me, as the warm weather came on in the ſpring, "it is almoſt time for the ſwallows to come out of the mud, where they have lain all winter." On my calling his philoſophy, once and again, in queſtion, and ſaying, as I formerly believed, that doubtleſs they were birds of paſſage, he has repeatedly aſſured me, he had, in the autumn of many years, ſeen great numbers of them, on one day only in each year, and nearly about, but not always on the ſame day of the month, ſitting on the willow buſhes, (which, by the way, they are not wont to rooſt upon at other times) on the borders of the river, a little after ſunſet :—That they ſeemed as if their torpitude had already begun, as they would not ſtir from the twigs, which, by the weight of the ſwallows, were bent down almoſt to the water ;—and that although he had never ſeen them ſink into it, yet he had waited till it was ſo dark that he could not diſcern them at all ; and doubted not of their immerſion any more than if he had been a witneſs of it ; for he had never obſerved any flying about afterwards, till the return of ſpring. He added, that if, as he wiſhed, I would carefully look out for their reſurrection, he believed it would not be in vain. He had, he ſaid, often taken notice that only a few appeared at firſt, and the main body in about a week after.

Although I paid little regard to it for ſome years, yet I followed his advice at length, and watched for their appearance ſeveral ſeaſons, as carefully as I could. I have not indeed beheld them riſing out of the water ; yet I and my family have, in more

more years than one, ſeen, at the proper time in the ſpring, very large flocks of them, in my own, and in my neighbour's land, ſo near the margin of the river, that, from that circumſtance, the appearance of their feathers, and their being unable to uſe their wings as at other times, we concluded they were newly emerged from the water. When they attempted to fly, they could not reach above eight or ten yards before they ſettled to the ground, and then might be drove about like chickens. They appeared unwilling to be diſturbed; and, if not frightened by ſome noiſe or motion, would cluſter together, ſeeming to want to reſt themſelves, as if feeble, or fatigued.—They were not entirely recovered from their ſtupor,—there was a viſcous ſubſtance on and about their wings,—or they were too weak to fly away. We had ſeen none in thoſe years before; but in each of them, after a day or two, they were flying about as uſual in ſummer.

In addition to the foregoing, I can aſſure you, on the moſt credible teſtimony, that there have been more inſtances than one of a pickerel's being caught in this river, at the ſeaſon of the coming of ſwallows, with one of thoſe birds in its belly.

I may poſſibly overrate theſe diſcoveries, yet, as I cannot overrate your candour, I hope to loſe no credit by communicating them to an old and faithful friend, who, though he ſhould not be informed, may poſſibly be amuſed by them.

I am, with the ſincereſt eſteem,

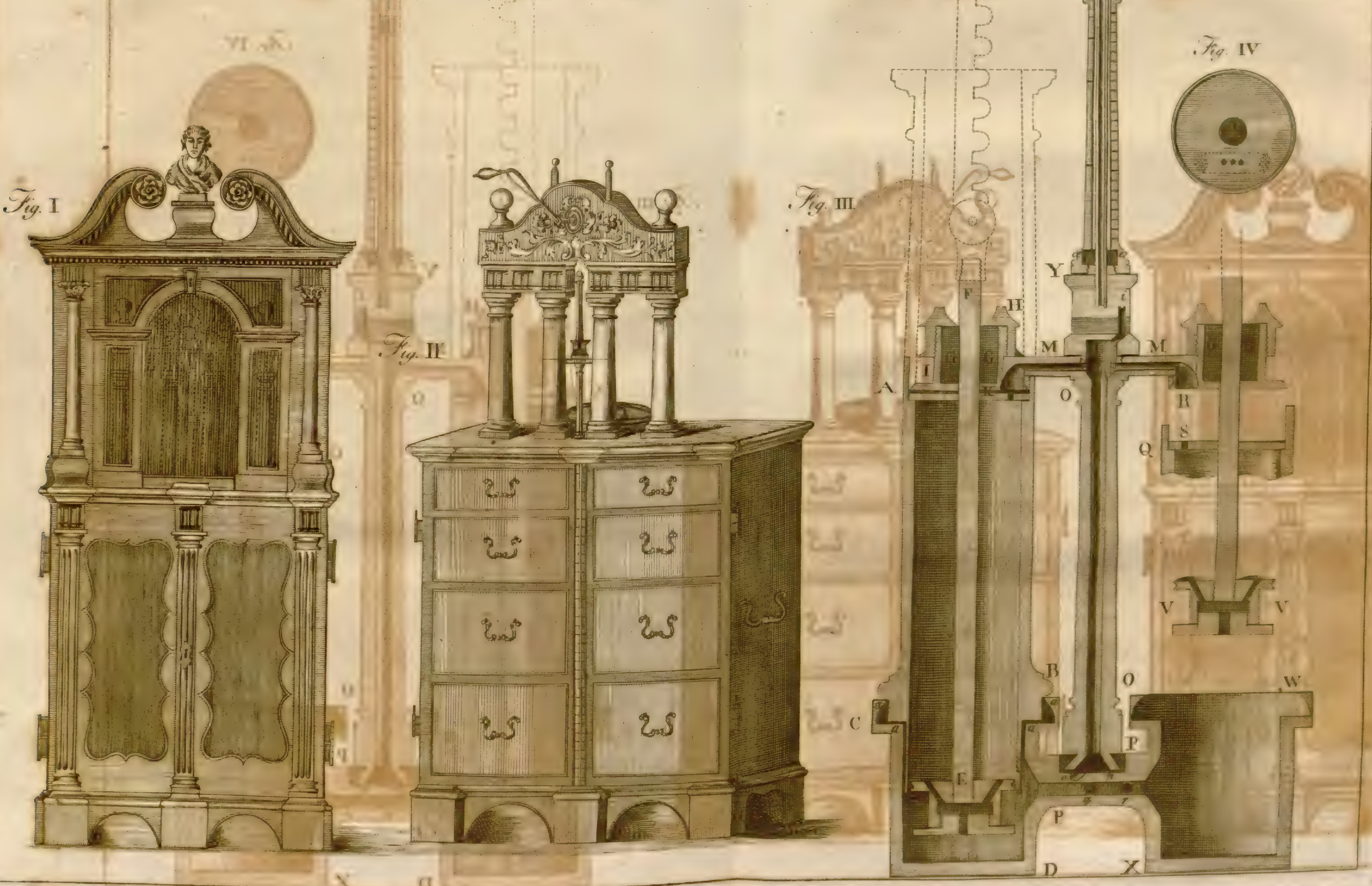
Sir, your moſt obedient ſervant.

SAMUEL DEXTER.

Facing p. 497

Plate 4

AIR PUMP



XXVI. *An Account of an Air-Pump on a new Construction; with some Observations on the common Air-Pump, and Mr.* SMEATON'S *improvement: In a Letter from the Rev.* JOHN PRINCE *to the Rev.* JOSEPH WILLARD, *President of the University of* Cambridge.

Salem, Nov. 10, 1783.

REV. AND DEAR SIR,

AGREEABLE to your request, I will endeavour to give you some account of the air-pump I have lately constructed, upon a plan different from any I have ever seen.

Reading the account of the ingenious Mr. *Smeaton's* air-pump, in vol. xlvii. of the Philosophical Transactions, and the high recommendation of it by Dr. *Priestley*, in vol. lxiv. of the same work, I was desirous of possessing one of that kind: but finding, by the Doctor's paper, they were not commonly made by the philosophical instrument-makers in *London*, it induced me to attempt making one myself, with such assistance as I could get here.

Before I had proceeded far, I thought Mr. *Smeaton's* pump might be improved, if not in its power of rarifying the air, at lest in simplicity. With this in view, I have finished mine. To show the ground on which I have gone, it will be necessary to consider the rationale of an air-pump, and make some observations on Mr. *Smeaton's*. It is well known that the valve at the bottom of the barrel of an air-pump is opened by the spring of the air acting against it underneath, when the weight of the air is removed from the top of the valve, by raising the piston in the barrel. In order to remove this resistance from the top of the valve most effectually, the piston should be made to fit very exactly to the valve-plate, when put down upon it: for if there be any space between the bottom of the piston and

 valve,

valve, part of the air will be retained in it; and this air, even when the piston is raised to the highest, will, by its expansion, in some measure, obstruct the opening of the valve. When the air in the receiver, or underneath the valve, is rarefied to an equal degree with the air contained in the barrel, (the piston being drawn up to the highest) the valve can rise no longer, because the resistance above is equal to the power below. The resistance from this air, retained in the barrel, against the valve at the bottom, will be uniformly the same, when the piston is at the same distance from it; because the weight of the atmosphere is continually pressing on the piston-valve, and will prevent the air below passing through it, while this air is rarer than the atmosphere: and when the piston is put down to the bottom of the barrel, it will not escape through the piston, but only be compressed into the vacancy between the bottom of the piston and the valve-plate at the bottom of the barrel, and be of equal density with the atmosphere. Besides the resistance arising from this retained air, we must consider the weight of the valve, its cohesion to the plate, occasioned by the oil, and its being stretched tight over the hole, as increasing the obstruction; especially when the spring of the air under the valve is much weakened by rarefaction. And if we take into the account the resistance arising from these causes, the density of the air in the barrel, when compressed into the abovementioned vacancy, will be as much greater than the density of the atmosphere above the piston, as the addition of this resistance; for this obstruction belongs to the piston-valve, as well as to the other. And so also, when this retained air is expanded, say one hundred times, by raising the piston, the air in the receiver cannot be rarefied to the same degree, because of this resistance of the valve at the bottom of the barrel.

In

In order to produce a greater rarefaction of the air in the receiver than what the common pump will effect, the valves, where used, must be made to open easier, by removing, as far as possible, these obstructions. In the common pump these impediments are great; because the surface of the valve, which is exposed to the air underneath, is generally very small; and the vacancy between the piston and the bottom of the barrel bears a greater proportion to the whole barrel than it would if the work were properly executed.

These imperfections Mr. *Smeaton* considered and endeavoured to remove in the construction of his pump. For this purpose he exposed a much larger surface of the lower valve to the air underneath, by forming a kind of grating in the plate. By this the cohesion was lessened, and more power could apply to open the valve in the first instant. The difficulty arising from the air retained in the barrel he removed, in a great measure, by making the piston fit more nicely to the bottom, and by taking the weight of the atmosphere from off the piston, which allowed the valve in it to be more easily opened, so that much more of the air could pass through it. The weight of the atmosphere he removed from the piston, by closing the top of the barrel with a plate, on which he fixed a collar of leathers; through this the cylindrical part of the piston-rod moves air-tight. And the air, having passed through the piston, is forced out of the barrel through a hole in the top-plate, over which is a valve to prevent the return of air, when the piston descends. The piston is made to fit as exactly to the top, as to the bottom of the barrel, to exclude the air more effectually.

By this improvement, Mr. *Smeaton* says, "I have been able to "rarefy the air one thousand times, when the pump was put

" clean together; and that it feldom failed of doing it five hun-
" dred, after it had been ufed for feveral months without clean-
" ing: whereas the degree of rarefaction produced by the beft
" common pumps never exceeded one hundred and forty times,
" when tried by my gage."

I have taken up much of your time in this account; but I hope you will not think unneceffarily, as it fhows the ground on which I have gone, and a defcription of Mr. *Smeaton's* pump is, in fome meafure, a defcription of mine.

Mr. *Smeaton* having done fo much to facilitate the opening of the valves, at the bottom of the barrel, and in the pifton, by which means he carried the degree of rarefaction much further than the common pump could do; I fuppofed, if thofe valves were entirely removed, and the remaining air in the barrel could be more perfectly expelled, the rarefaction might be carried ftill further. Upon this plan I have conftructed my pump. I have removed the lower valve, and opened the bottom of the barrel into a ciftern, on which it is placed, and which has a free communication with the receiver. For the valve on the plate, at the top of the barrel, (which is conftructed like Mr. *Smeaton's*) makes it unneceffary there fhould be any at the bottom, in order to rarefy the air in the receiver.

The ciftern is deep enough to allow the pifton to defcend into it, below the bottom of the barrel. Suppofe then the pifton to be folid; that is, without a valve in it; when it enters the barrel and rifes to the top plate, which is made air-tight with a collar of leathers, &c. like Mr. *Smeaton's*, it forces out all the air above it; and as the air cannot return into the barrel, on account of the valve on the top-plate, when the pifton defcends there will be a vacuum formed between that and the

plate;

plate; every thing being supposed perfect. But in working the pump, the piston is not allowed to descend entirely into the cistern, so far as to leave the bottom of the barrel open; because, as the cistern, for another purpose, is made larger than the bore of the barrel, this might make the piston-rod work unsteadily in the collar of leathers, and cause it to leak: but it descends below a hole in the side of the barrel, near the bottom, which opens a free communication between the barrel, cistern, and receiver. Through this hole the air rushes from the cistern into the exhausted barrel, when the piston has dropped below it; and by its next ascent this air is forced out as the other was before. If now the capacity of the receiver, cistern, pipes, &c. below the bottom of the barrel, taken together, be equal to the capacity of the barrel, half the remaining air will be expelled by every stroke.

But as the working a pump of this kind, with a solid piston, would be laborious, on account of the resistance it would meet with in its descent from the air beneath, (though this would be lessened by every stroke, as the air became more rarefied) I have, to remedy this inconvenience, pierced three holes in the piston, at equal distances from each other; and a circular piece of bladder, which is tied over the top of the piston, to make the joint more perfect with the top-plate, and to defend them from injury when the piston is brought up against it, forms a kind of valve over the holes, which open easy enough to prevent any labour in working the pump, as it allows the air to pass through the piston when it descends. But the air does not necessarily depend upon a passage through the piston in order to get into the barrel: for when the air becomes so weak, from its rarefaction, that it cannot open this valve, it will still get into the barrel

rel when the communication is opened by the hole at the bottom. This piſton, therefore, will deſcend as eaſy as any other; and this valve does not impede the rarefaction; ſince it is of no conſequence, as to this, whether it open or not. By this conſtruction, the valves, which Mr. *Smeaton* only made to open with more eaſe, are rendered unneceſſary in rarefying the air: and that at the bottom of the barrel, which is the moſt difficult to be made and kept in order, is entirely removed; that on the top-plate being the only one neceſſary in rarefying the air.

But as in a ſingle barrelled pump of this conſtruction, where there is no valve at the bottom to prevent the air, which follows up the piſton in its aſcent, from returning into the receiver in its deſcent, a fluctuation would be produced, which might prove detrimental in ſome experiments, this pump is made with two barrels, which rarefies the air at every ſtroke of the winch. In this conſtruction, the capacity of the two barrels, taken together, below the piſtons, is always the ſame; for while one is deſcending, the other is aſcending; and what is taken from the one is added to the other.

Having thus ſet aſide the valves, which in ſome meaſure prevented the air from getting into the barrel and above the piſton, I next attempted to expel the air more perfectly out of the barrel than Mr. *Smeaton* has done, by making a better vacuum between the piſton and the top-plate, which would allow more of the air to expand itſelf into the barrel from the receiver. But to ſhow in what manner I have attempted this, it will be neceſſary to give ſome further deſcription of the machine.

I have, upon Mr. *Smeaton's* plan, contrived to connect the valves on the top-plates with the receiver, occaſionally, by means

means of a pipe and cock, by the turning of which, the machine may be made to exhauſt or condenſe at pleaſure. This is done in the following manner: There is a croſs-piece laid over the valves, extending from one barrel to the other, which has a duct through it, connected with a ſmall pipe ſtanding between the barrels: through this pipe the air paſſes into a duct in the bottom-piece leading to the cock. In this piece is likewiſe the duct leading from the ciſtern to the cock; and with this cock alſo is connected the pipe leading to the receiver. The key is pierced with two holes in ſuch a manner, that one of them will connect the pipe coming from the receiver with the duct in the bottom-piece leading to the ciſtern, or with the other leading to the valves, as may be required for exhauſting, or condenſing. The other hole through the key will open, occaſionally, to the atmoſphere, either of theſe ducts round the cock. So that having the direction of the air which paſſes through the valves, under the command of this cock, the pump may exhauſt or condenſe at pleaſure: for when the key connects the pipe from the receiver, and the duct leading to the ciſterns together, the pump will exhauſt; and when it connects the pipe with the duct leading to the valves, it will condenſe; as the other hole in the key, at the ſame time, opens to the atmoſphere the duct leading to the ciſterns, by which paſſage the air enters the barrel from the atmoſphere, is forced out at the valves, and through the pipe and cock into the receiver. In this part of the machine which is contrived for condenſation, I have, by an additional part, endeavoured to get the air more perfectly out of the barrel.

We have ſeen that Mr. *Smeaton*, by making the piſton of his pump fit more exactly to the bottom of the barrel, and by

ſhutting up the top to prevent the preſſure of the atmoſphere on the piſton-valve, was able to get more of the air above it than could be effected in the common pump. But ſtill the difficulty, though ſo far removed, remains in the top of the barrel: for as the piſton cannot be made to fit ſo exactly to the top-plate, but that there will be ſome lodgment for air, it is impoſſible to expel it entirely; more, perhaps, might be expelled if the valve on the top could be made to open more eaſily, by removing the weight of the air from it; for the atmoſphere, preſſing on this valve, will prevent its opening freely, in the ſame manner as when preſſing on the piſton-valve, it obſtructs the opening of that in the common pump.

The difficulty which Mr. *Smeaton* removed from the piſton-valves, I have endeavoured to remove from the valve on the top-plate; that this valve, having the preſſure of the atmoſphere taken off, might open with the ſame eaſe as the piſton-valve does in his pump. To effect this, there is connected with the duct on the bottom-piece, which conveys the air from the valves to the cock, a ſmall pump of the ſame conſtruction as the large one; having the barrel opening into a ciſtern, the piſton-rod moving through a collar of leathers, and a valve near the top, through which the air is forced into the atmoſphere. This piſton is ſolid; becauſe the diameter, being only half-inch, does not make it work hard. This pump, which is of one barrel only, I call the valve-pump; its chief uſe being to rarefy the air above the valves, or remove the weight of the atmoſphere from off them. To uſe this pump, it is neceſſary the key of the cock ſhould be pierced differently from that of Mr. *Smeaton's*; for as the pipes round his are placed at equal diſtances, when the one from the bottom of the barrel is connected with

with that from the receiver to exhaust it, the other, from the valve on the top-plate, is opened to the atmosphere by the other passage through the cock. But in order to rarefy the air above the valve in my pump, it is necessary this last passage should be shut up, when the valve-pump is used. Instead, therefore, of placing the three ducts at equal distances round the cock, I have divided the whole into five equal parts; leaving the distance of one-fifth between the ducts leading from the cistern and the valves to the cock, and two-fifths between each of these and the one leading from the cock to the receiver. By this adjustment, when the communication is open between the receiver and valves, for condensation, the other hole through the cock opens the cisterns to the atmosphere: but when the communication is made between the cisterns and the receiver, for exhaustion, a solid part of the key comes against the duct leading to the valves, and shuts it up; and the air, which is forced out of the barrel, passes into the atmosphere through the valve-pump; for the valve of the small pump may be kept open while the great one is worked.

Now, to apply Mr. *Smeaton's* reasoning to this construction. After mentioning his taking off the weight of the atmosphere from the piston, by shutting up the top of the barrel, he says, "The consequence of this construction is, that when the piston is put down to the bottom of the cylinder, the air in the lodgement under the piston will evacuate itself so much the more, as the valve of the piston opens more easily, when pressed by the rarefied air above it, than when pressed by the whole weight of the atmosphere. Hence, as the piston may be made to fit as nearly to the top of the cylinder, as it can to the bottom, the air may be rarefied as much above the piston

" as it could before have been in the receiver. It follows, " therefore, that the air may now be rarefied in the receiver, " in duplicate proportion of what it could be upon the com- " mon principle; every thing elſe being ſuppoſed perfect." The ſame may be ſaid with regard to the valve on the top-plate in this machine. It will open more eaſily, when preſſed by the rarefied air above it, than when preſſed by the weight of the whole atmoſphere. Hence, as by the conſtruction of the valve-pump the air may be rarefied as much above the valves, as it could before have been in the barrel and receiver, with which there is a free communication: it therefore follows, that the air may now be rarefied in the receiver in duplicate proportion of what it could be by Mr. *Smeaton's* pump; every thing elſe being ſuppoſed perfect; and the nature of the air permitting it.

In this eſtimation, any advantage which may ariſe from the removal of the valves at the bottom of the barrels and in the piſton, is not conſidered: But if they made any reſiſtance in Mr. *Smeaton's* pump, may we not conclude, that the rarefaction might be carried further by a machine wherein no ſuch valves are made uſe of? Mr. *Smeaton* ſays, that when he contrived to open his valves by the winch, independent of the ſpring of air, he did not find it anſwer the purpoſe better than when the air was the agent. There is no reaſoning againſt experiment: but it certainly appears probable from theory, that there muſt be conſiderable reſiſtance from the valves when the air is greatly rarefied.

He afterwards ſays, " the degree, to which I have been able " to rarefy the air, by experiment, has generally been about one " thouſand times, when the pump is put clean together: but

" the

"the moisture that adheres to the inside of the barrel, as well
"as the other internal parts, upon letting in the air, is, in the
"same succeeding trials, worked together with the oil, which
"soon renders it so clammy as to obstruct the action of the
"pump, upon a fluid so subtle as the air is, when so much
"expanded.—But in this case it seldom fails to act upon the
"air in the receiver, till it is expanded five hundred times : and
"this I have found it to do, after being frequently used for several
"months without cleaning." Does it not appear probable, that this clamminess must have a bad effect upon the valves, as well as the other internal parts of the pump, in those same succeeding trials ? and that the stiffness which the oil acquires by evaporation, the corrosion of the brass, &c. when the pump is foul, must greatly obstruct the opening of the valves, and bear a principle part in reducing the rarefaction from one thousand to five hundred times ?

I supposed the valves to be a great obstruction, and have endeavoured to avoid them : and if no further advantage be derived from it, the machine is more simple without them.

Upon this construction, also, we are able to make the pump with two barrels, like the common pump, which cannot be done conveniently where the lower valve is retained ; because it would be difficult to make the piston in one barrel come exactly to the bottom, at the same time that the piston in the other touched as exactly at the top : it would, at least, require a nicety in the workmanship, which would be troublesome to execute.

In this pump, the pistons do not move the whole length of the barrels : there is a horizontal section made in them, a little more than half way from the bottom, where the top-plates are inserted

inſerted. By this mean the pump is made more convenient and ſimple, as the head of it is brought down upon the top of the barrels, in the ſame manner as in the common air-pump. The barrels alſo ſtand upon the ſame plane with the receiver-plate; and this plane is raiſed high enough to admit the common gage of thirty-two or three inches, to ſtand under it, without any inconvenience in working the pump, as the winch moves thro' *a leſs* portion of an arch, at each ſtroke, than it would if the piſtons moved the whole length of the barrels.

There is alſo placed, between the barrels in this pump, on the croſs-piece over the valves, a gage to meaſure the degree of condenſation, having a free communication with the valves, cock, &c. This gage is ſo conſtructed, that it will alſo ſerve to meaſure the rarefaction above the valves, when the air is worked off by the valve-pump. It conſiſts of a pedeſtal, which forms a ciſtern for the mercury, a hollow braſs pillar, and glaſs tube, hermetically ſealed at one end, which moves up and down in the pillar, through a collar of leathers. The dye of the pedeſtal is made of glaſs, as well to hold the quickſilver, as to expoſe its ſurface to view, that it may be ſeen when the open end of the tube is put down into it, or raiſed out of it. The body of the pillar is partly cut away to expoſe the tube to view in the ſame manner.

If the pump be uſed as a condenſer, the degree of condenſation is ſhown by a ſcale marked on one edge of the pillar: if it be uſed as an exhauſter, the degree of the rarefaction of the air, above the valves, is ſhown by a ſcale marked on the other edge of the pillar.

This gage will alſo ſerve to ſhow when the valves have done playing, either with the weight of the atmoſphere on them,

or taken off. If we want to know when they cease opening, with the weight of the atmosphere on them, draw the piston of the valve-pump up into its barrel, to prevent any air escaping through that valve; in this situation, work the great pump again, and if any air passes through the valves into the pipe, the gage will rise by condensation. This condensed air must then be let out by opening the communication, at the cock, with the outward air. By repeating this till the gage rises no longer, we may know the valves will open no more while the weight of the atmosphere lies on them; and the rarefaction in the receiver can be carried no further. When the weight of the atmosphere is to be removed, after conducting as in the former experiment, raise the open end of the tube above the surface of the mercury, and then work the valve-pump, and the air will be rarefied over the valves, and in the tube, to the same degree: (we may see when the valve of this pump has done playing by unscrewing the cap that covers it.) The open end of the tube is then to be immersed into the mercury, and the great pump worked. The air which passes thro' the valves will then raise the gage by condensation: and thus, by alternately raising and depressing the tube, and working the two pumps in their turns, we may carry the rarefaction of the air in the receiver as far as the power of the pump will go. If one of Mr. *Smeaton's* pear-gages be used in the receiver, as he directs, the difference of the rarefaction, in the two experiments, may be known. And as the air above the valves may be rarefied to different degrees, we may know, by the two gages, what proportion the rarefaction above the valves bears to the degree of excess in the receiver. This condensing gage can be taken off, and a button screwed into the hole in its stead, in any case wherein a greater degree of condensation is required than

the

the glaſs will bear. When a glaſs receiver is uſed, this gage may be placed within it, where it will meaſure any degree of condenſation the receiver will bear, without danger to the gage: or the capacity of any receiver may be meaſured by this gage, before it is removed from its place, by ſhowing how many ſtrokes of the winch will throw one atmoſphere into the receiver; then turning the cock, to prevent any air eſcaping, change the gage for the button: when this is done, the degree of condenſation may be further meaſured by the number of ſtrokes.

As in caſes where great condenſation is required, there muſt be a great deal of labour, and a great ſtrain on the teeth of the wheel and piſton-rods, on account of the great diameter of the piſtons; * to remedy this, I have fitted a condenſer, of a ſmaller bore than the barrel of the great pump, to the ciſtern of the valve-pump, to be ſcrewed on occaſionally; by which the condenſation may be finiſhed, inſtead of the great pump. Or, to ſave the work and expence of this condenſer, the valve-pump, if made a little larger, may be eaſily fitted for the ſame purpoſe, by having a plate made to ſcrew into the bottom of the cylinder, occaſionally, with a valve on it, opening into the ciſtern: a hole muſt alſo be made to be opened, on the ſame occaſion, near the top of the cylinder, to let air in below the piſton, when this is drawn up above it.

The common gage, which is generally placed under the receiver-plate, in this pump, is placed in the front; that it may be ſeen by the perſon who is working the pump, and that the plate may be left free for other uſes.

The

* In my pump, the piſtons are two inches diameter; ſo that there will be about forty-eight pounds added to the reſiſtance in opening the valves, for every atmoſphere thrown into the receiver.

The plate is ſo fixed to the pipe, leading to the cock, that it may be taken off at pleaſure, and uſed as a transferer; or any tube, or apparatus, may be fixed to it, to perform ſome experiments without removing it, which will ſave trouble, and make leſs apparatus neceſſary.

The head of this pump is not divided, as the common one is, to diſlodge the teeth of the wheel from the piſton-rods, when the pump is to be taken apart; but is made whole, except a ſmall piece in the back, where the wheel is let in; which makes it much more convenient to remove the head, or place it on the barrels. The wheel is freed from the piſton-rods, when required, by puſhing it into the back part of the head; and when it is drawn into its place and connected with them again, a button is ſcrewed into the ſocket of the axis behind, to keep it in its place. This makes the head leſs troubleſome to remove: but its chief uſe is to diſlodge the piſton-rods from the wheel, that they may be put down into the ciſterns, when the pump is not in uſe, where they will ſtand uncompreſſed, and retain their elaſticity better than if kept in the barrels. In theſe ciſterns they may alſo ſtand covered with oil, if neceſſary, as they are large enough to admit of it.

The principal joints of the pump are ſunk in ſockets, that the leathers, which cloſe them, may be covered with oil, to prevent leaking.*

For convenience, the lower part of the pump is fitted with drawers, to contain the apparatus. A door opens behind one range

* This, I find, is very effectual; having never known one of the joints, ſecured in this way, to leak, though the pump has ſtood for a long time: whereas a portable pump which I have, made by Mr. *Nairne*, *London*, has leaked, and repeatedly been refitted with new-oiled leathers, in the ſame time.

range, to a place reserved the whole height, to get at the under part of the receiver-plate, and fix apparatus to it for some experiments. In this place stand the long tubes, and such tall glasses, belonging to the apparatus, as will not go into the drawers. The barrels, &c. of the pump are covered with a case, or head, which keeps them from dust and accident, when the pump is not in use. The apparatus is secured between sliders, &c. in the drawers, so that the whole machine may be easily removed, in one body, without danger.

Having given you this account of the machine, I wish, Sir, I could add to it, at this time, the result by experiment, and inform you to what degree it will rarefy the air; but the want of a proper apparatus to measure the rarefaction, prevents me.

As we have no glass-manufactory here, I sent to *Europe* for my apparatus, about twelve months since: but, unluckily, this part, with some others, have not yet been forwarded to me. As soon as I can satisfy myself, I will let you know the result. I have, at present, only a small tube of two-tenths inch bore, I accidentally met with, which I use as a common gage: but this will not determine the power of the pump.

All I can say of the instrument at present is, that I find it much more convenient to use than one of the common sort: that it will exhaust a receiver much sooner, and keep in order much longer, for being made without valves, which must depend on the spring of the air to open them. When a common pump, which I have, has been fitted up with valves, leathers, &c. at the same time with this; the valves of the common pump have become too dry and stiff to use, while this pump has continued in good order. I attribute this, in part, to the moisture which the valves on the top-plates receive from the

pistons

pistons every time the pump is used; the pistons being always kept moistened with oil in the cisterns, where they stand when the pump is not in use; and in part, to the power which the pistons have over these valves, by condensing the air against them. In the common pump, and in Mr. *Smeaton's*, the valves, at the bottom of the barrels, can only be opened by the spring of the air acting against them: but in this pump the valves are forced open, by raising the pistons, and must, therefore, yield much longer to the power applied in this way.

I mentioned above, that the pistons in this pump did not move the whole length of the barrels; but were interrupted by the plate, a little more than half way from the bottom, for convenience: but on this construction, they may be made to move through the whole length, as in Mr. *Smeaton's* pump; and then it will exhaust a receiver in half the time that his will, if the capacity of each barrel in the two pumps be equal. And perhaps the air may be further rarefied by a pump on this construction without the valves, whose barrels are of greater length than the barrels of my pump. For since the piston may be made to fit as well to the top of one barrel as another, if the length of the barrel, through which the piston moves, be twelve inches instead of six, the vacancy, which is unavoidably left between the top-plate and the piston, when the latter is drawn up to the former, will bear a less proportion to the capacity of the whole barrel. Suppose, then, the valve on the top-plate will rise only till the air be expanded one hundred times in a barrel of six inches length, because this is the proportion which the vacancy bears to the capacity of the whole barrel, (the resistance of the valve not being taken into the account) it will rise till the air is expanded two hundred times in a barrel of twelve inches

length, the diameters being the ſame in both, becauſe the capacity of the barrel being doubled, the vacancy bears ſo much leſs proportion to it than to one of ſix inches. And if the air can be rarefied in proportion to the difference between the vacancy and the capacity of the barrel, by leſſening this proportion, which, after having made the work to fit as well as poſſible, is to be done by enlarging the capacity of the barrel, the power of the pump muſt be increaſed.

This, Sir, is reaſoning from theory: but theſe circumſtances, I think, ought to be conſidered in the conſtruction of an air-pump; and experiment only muſt determine how far an attention to them may be uſeful.

The rarefaction which a pump will produce, by experiment, may come very far ſhort of what it ought to do by the theory of its conſtruction. If the common pump will, in experiment, rarefy the air only one hundred times, when in its beſt ſtate, and Mr. *Smeaton's*, by conſtruction, in duplicate proportion to this, it ought to go to ten thouſand; every thing being ſuppoſed perfect: but in its beſt ſtate, Mr. *Smeaton's* pump will only rarefy the air about one thouſand times; ſo that the nine-tenths which it falls ſhort of what it ought to do by theory, is to be attributed either to the imperfection of the machine alone, or to the nature of the air, in not permitting the rarefaction to go further than one thouſand times, or both theſe cauſes together. The way to prove how far this is owing to the air itſelf, is by making a machine, which, in theory, will carry the rarefaction further. A pump conſtructed without the valves, as mine is, ought to rarefy the air in duplicate proportion of what Mr. *Smeaton's* ſhould do by theory, and in quadruplicate proportion of the common pump, which would be one hundred million,

allowing

allowing the common one to rarefy the air one hundred times. Nothing like this, however, is to be expected, since we see Mr. *Smeaton's* pump, in experiment, falls so far short of the theory. But supposing my pump to rarefy the air in duplicate proportion of what Mr. *Smeaton's* does by experiment, this would carry the rarefaction to one million times: and whatever it falls short of this, must be attributed either to the imperfection of the machine, or the nature of the air, or both together: or if this pump should rarefy the air only to the same degree with Mr. *Smeaton's*, since by construction it ought to go so much further, will it not ascertain to us, in a direct line, that the nature of the air does not admit of being further rarefied by a pump; and that this is the reason why Mr. *Smeaton's* pump, in experiment, fell so far short of the theory? If this should be the case, will it not be a confirmation that the power of mechanism is not wanting to produce a much greater rarefaction in the receiver, where no body acts immediately upon the air to expel it, and from which place it can only be induced to come, by making room for its expansion into some other? I hope, in a little time, to be able to inform you what the result is by experiment, and to what degree this pump will exhaust the receiver.

I am, &c.

JOHN PRINCE.

NOTE. Since this letter was communicated, I have seen, in the 67th vol. of the Philosophical Transactions, an account of some experiments made by Mr. *Nairne*, with a pump constructed on Mr. *Smeaton's* principle: from which it appears that Mr. *Smeaton* was deceived with respect to the rarefaction in his receiver, as indicated by the pear-gage; and that the greatest power of the pump, when the experiment was properly made, would carry the rarefaction in the receiver only to six hundred, instead of

AN EXPLANATION OF THE PLATES.

PLATE IV. Fig. 1. A view of the pump ſhut up, when not in uſe; appearing through a glaſs window, as ſhewn by the pricked lines.

Fig. 2. A view of the pump when opened and uncovered for experiments.

Fig. 3. A perpendicular ſection of one of the barrels, the two ciſterns, condenſing gage, &c. where A B repreſents the barrel: C D the ciſtern on which it ſtands; *a a a a* the leathered joint, ſunk into a ſocket, and buried in oil: E F is the piſton; the cylindrical rod paſſing through a collar of leathers, G G, in the box H I. K ſhows the place of the valve on the top-plate K L, covered by the croſs-piece M M, into which the pipe O O is ſoldered; that conveys the air from the valves to the duct going under the valve-pump, as may be ſeen in plate V. fig. 1. *o* is part of the ſaid duct; *p* is the joint ſunk into a ſocket in the croſs-piece P P, which connects the ciſterns and has a duct through it leading to them. Into this duct open the ducts *q* and *r*, the firſt leading to the gage in front of the pump, the other to the cock and receiver.

of one thouſand times. By an account of Mr. *Cowallo's*, in the 73d vol. of the Philoſophical Tranſactions, I find an improvement made in Mr. *Smeaton's* pump, by Mr. *Haas*, inſtrument-maker. He has contrived to open the valve at the bottom of the barrel independent of the ſpring of the air underneath; and by this improvement he has increaſed the power of the pump to one thouſand times. This experiment is a confirmation of what is to be expected from the removal of the valve in my pump, which is done with greater ſimplicity, as Mr. *Haas's* contrivance is complex, conſiſting of a ring lying at the bottom of the barrel, to which ring the valve is faſtened; this ring is raiſed by a pedal, connected with two wires moving through two collars of leathers, and is depreſſed by a ſpiral ſpring contained in a ſocket, the whole being fixed under the barrel of the pump: But he has done nothing to remove the reſiſtance from the valve in the piſton, nor the weight of the atmoſphere from off the valve on the top-plate.

The other barrel is left out of the figure, to ſhow ſome of the parts more diſtinctly; except Q Q, which is the top of the barrel retained and brought down out of its place, to ſhow the top-plate, that ſhuts up the barrel, ſeparated from the box, which contains the collar of leathers. S ſhows one of the holes in the plate over which the valve lies, and which is covered by R in the croſs-piece. V V is the piſton ſhowing the valve open on the top, which is to prevent labour when the pump condenſes. W X is the ciſtern, in which is more diſtinctly ſeen the ſhoulder for the leather which cloſes the joint between this and the barrel, and alſo the ſocket in which the oil lies over the leather. Y Z is the condenſing gage, with the orifice of the tube raiſed above the ſurface of the quick-ſilver. *e e* is the collar of leathers, through which the glaſs tube moves. *i* is a ſmall pipe coming up through the quick-ſilver to make a communication between the valves and the gage.

Fig. 4. is a view of the upper ſurface of the top-plate which cloſes the barrel, being ſoldered into it, ſhowing the place of the valve over the three ſmall holes, one of which only can be ſeen at S, in fig. 3.

Plate V. fig. 1. is a perpendicular ſection of the bottom-piece, pipes, valve-pump, cock, &c. at right angles with the other ſection, fig. 3. pl. IV. A B is the pipe between the barrels, as repreſented in plate IV. The button *o* is here ſcrewed into the top inſtead of the gage. C D is the valve-pump and its ciſtern, *e* the place of the valve under the cap. E F the cock, ſhowing the duct through it leading to the atmoſphere. G H the pipe leading from it to the ſtem of the receiver-plate, in which is the cock I, to ſhut up the duct when the plate is uſed as a transferer. K K is the plate. L a piece to ſhut up the

the hole into which tubes, &c. are occasionally screwed to perform experiments without removing the plate: the pricked line at O shows the place of the screw which presses the plate against the pipe: P Q the pipe and common gage standing in front of the pump.

Fig. 2. is a horizontal section of the cock and pieces, containing the ducts leading from it to the receiver, the cisterns, and the valves on the top of the barrels. A B the duct connecting the cisterns together. C D the duct leading from the cisterns to the cock. G H the duct leading from the cock, through the pipe A B, (fig. 1.) to the valves. D E the duct through the cock, which occasionally connects the two last-mentioned ducts with the duct E F, leading from the cock to the receiver. I the duct in the cock leading to the atmosphere, which, when connected with the duct at D, lets the air into the cisterns and barrels for condensation; the other duct through the cock at the same time connecting H and E. This duct also, when connected with E, restores the equilibrium in the receiver. K L is part of the duct leading from the cisterns to the gage. The pricked circles show the places of the pipe and valve-pump on the piece, and *r* the place where the air enters the valve-pump from the duct G H, and is thrown into the atmosphere, when the pump exhausts.

Fig. 3. shows the under surface of the boxes, which contain the collars of leathers, with the cross-piece, which connects them together, having a duct through it, as represented by the pricked line, through which the air passes from the valves to the pipe: this fig. is designed chiefly to show the places in which the valves play, as at I.

Fig.

Fig. 4. is a side view of the pump, showing the situation of the valve-pump and handle of the cock; where A is the pump, and B the handle.

Fig. 5. is the top-plate which screws the key of the cock into its shell, and keeps it tight: the upper surface of it is marked with directions to turn the key so as to produce the effect desired: for when the mark on the key agrees with the mark on the plate, the pump exhausts, and so of the rest.

XXVII. *A Description of a Pump-Engine, or an Apparatus to be added to a common Pump, to answer the Purpose of a Fire-Engine; invented by Mr.* BENJAMIN DEARBORN: *Extracted from his Letters to the Hon.* JAMES BOWDOIN, *Esq; President: communicated by the President.*

Portsmouth, *November* 5, 1781.

SIR,

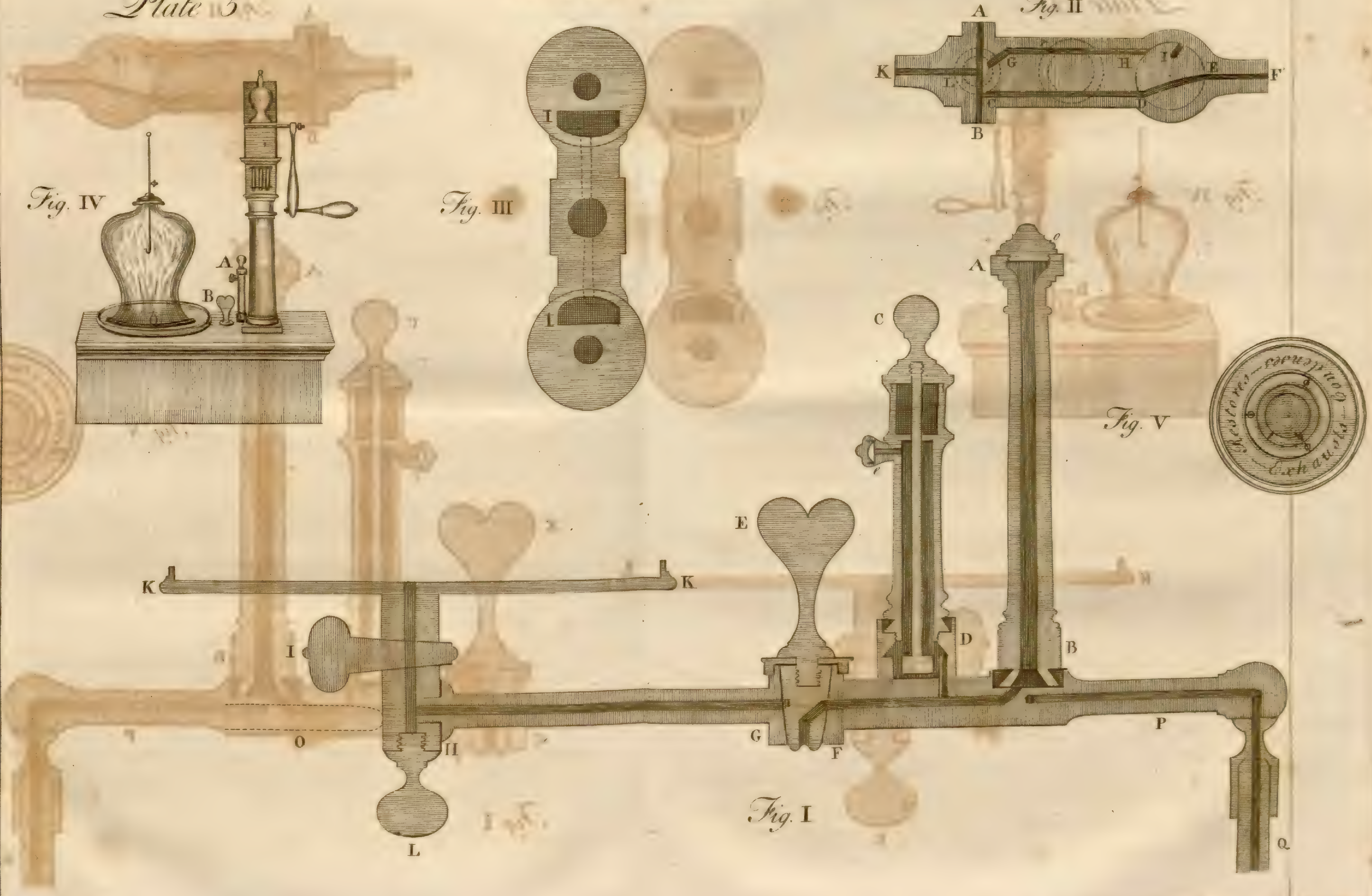
I HAVE spent some time in inventing the pump-engine, a model of which I have forwarded herewith. This engine is described as follows.

Plate VI. Fig. 3. A B C D represents a pump in the form of a common ship-pump. E its spout. F a stopper. D *d* is a plank cap, fitted with leather under it to the pump, and screwed down by the screws *a b*; having a hole in the center for the spear of the pump to pass through, round which a leather collar is made, as *c*. *g* is a nut for the screw *b*. *f b* is a square piece of wood, nailed across one end of the cap, the screw *a* passing through it and the cap; through this piece and the cap a hole is made, communicating with the bore of the pump. G G is a wooden tube (of any required length or number of joints) made square at the lower end, and hollowed to receive the cock, the upper end being made with a nice shoulder. *e* is a wooden cock, which opens or shuts the communication between the pump and the tube, having a handle on the opposite side, with a lock if necessary. *h h* are ferrules to prevent the tube from splitting. H H are braces, each of which must have another crossing it as nearly at right angles as may be. *i i* are irons in the form of a staple, going round the tube and through the braces, having holes in their ends for forelocks. K L M N is a head made of five pieces of wood, viz.

k l m n

AIR PUMP

Plate 15



k l m n, a ſquare piece, with a hole in the lower end, to receive the end of the tube, and reſts on the ſhoulder *o p*; on the lower end of this head a leather is nailed, having a hole in its centre ſimilar to the hole in the wood; another leather of the ſame form is put on the top of the tube, and a circle of thin plate-braſs between them; the two leathers and the braſs being preſſed between the lower end of the head and the ſhoulder of the tube; their edges are repreſented by *o p*. K N and L M are the edges of two pieces of plank which are as wide as the head, and nailed faſt to it, each of them having a tennon going through a mortice in the end of the piece O P; each tenon has a hole for a forelock at *q q*. O P is a piece of plank as wide as the ſides, having a hole in its centre through which the tube paſſes, and a mortice on each end for the tennons to paſs through. N M is a cap. *r r* are two pieces nailed on the ſide of the tube, with a truck in the lower end of each, to leſſen the friction of the head in its horizontal revolution. *q q* are forelocks to wedge the head down, and prevent the water from finding a paſſage out at the joint *o p*. Q R is a wooden conductor; the end Q being ſolid, the end R bored with a ſmall auger, *s* is a bolt going through the conductor and head, ſecured on the back with a forelock or nut; this bolt is round near the head and ſquare in the middle. *t u w x* is a piece of iron or braſs to prevent the head of the bolt from wearing into the wood. S S are ropes to direct the conductor.

Fig. 4. is the head without the conductor; *a b c d* is a thick braſs plate perforated to prevent dirt from cloging the conductor, and nailed with leather under it to the head. The ſquare hole in the centre is made to the ſize of the bolt, and prevents it from turning. The conductor has a hollow cut

round the bolt on the inside, as large as the circle of holes in the brass, round which hollow on the face of the conductor, a leather is nailed which plays on the margin of the brass plate, when the conductor turns.

I have raised a tube of 30 feet on my pump, but the severity of the season prevents my compleating it; having so far executed it only, as for one person to work at the brake; I can myself throw water on the top of a neighbouring building, the nearest part of which is 37 feet from the pump, and between 30 and 40 feet high.

XXVIII. *A Description of a Fire-Engine of a new Construction, by the same. Extracted from a Letter to the same.*

Portsmouth, *January* 28, 1782.

SIR,

HAVING constructed a model of a portable fire-engine, on the same principles as the pump-engine, I do myself the honour to forward you a description of it.

Plate VI. Fig. 1. A B and C D are the edges of two planks, confined together by four bolts. *a b c d* are two cylindrical barrels: in each of these barrels a piston with a valve is fastened to the spear *e*, and is moved up and down alternately by the motion of the arms E E. Under each barrel a hole is made through the plank A B, and covered with a valve. E E are arms hung on the common centre *f*. Arms parallel to these are on the opposite side. *g* is the end of a handle which is fastened across the ends of the arms. A bolt at *h* goes across from arm to arm; to this bolt the piece *i k* is fastened, and plays upon it; the lower end of this piece is fastened to the top of the spear *e*. G *l f* is a standard to support the arms; another answering to it on the opposite side, both being notched into the edges of the planks, are sufficiently secured by one bolt going through them at *l*, and having a nut or forelock on the opposite side. H I H I are square braces, which answer the purpose of ducts, through which the water ascends from the barrels through the plank at *m*. K L K L are irons in the form of a staple to confine the braces; the lower ends of these irons meet, and are secured with one bolt going through them and M N *n o*, which is a piece going up through a mortice in the centre of the planks; this piece is square from the lower end upward as high as the top of the braces; from thence to the top it is cylindrical; the

upper end being bored hollow, far enough down to communicate with the braces. O P is an iron ring going round the tube, having two ſhanks going up through the head, with ſcrews on the top at *p q*. *r s* is a ferrule nailed round the tube. The head and pipe are ſo nearly ſimilar to thoſe of the pump-engine that they need no further deſcription.

Fig. 2. is the ſame engine; the arms and ſtandards being taken off to give a more intelligible deſcription of the mode of ſecuring the braces, which is effectually done by one wedge driven into the mortice *a*, under the upper plank. *b* is a hole for the bolt to paſs through which ſecures the ſtandards. In this figure a ſide view of the head is given, with the pipe in a perpendicular direction.

The work is confined within a box ſet on wheels as common. The whole is made of wood except the ſpears of the pumps and a few bolts, &c. This model throws water about the ſame diſtance as the miniature pump-engine, the pumps being of the ſame bore. Engines on this conſtruction may be made in any place where a common pump can; and the inſide work will not be more than one quarter the coſt of thoſe on the uſual conſtruction; and the labour of working them will (as I conceive) be much leſs than in the others; theſe conſiderations may perhaps recommend them to ſome attention.

Facing p. 524

Plate 6.

Fig. I

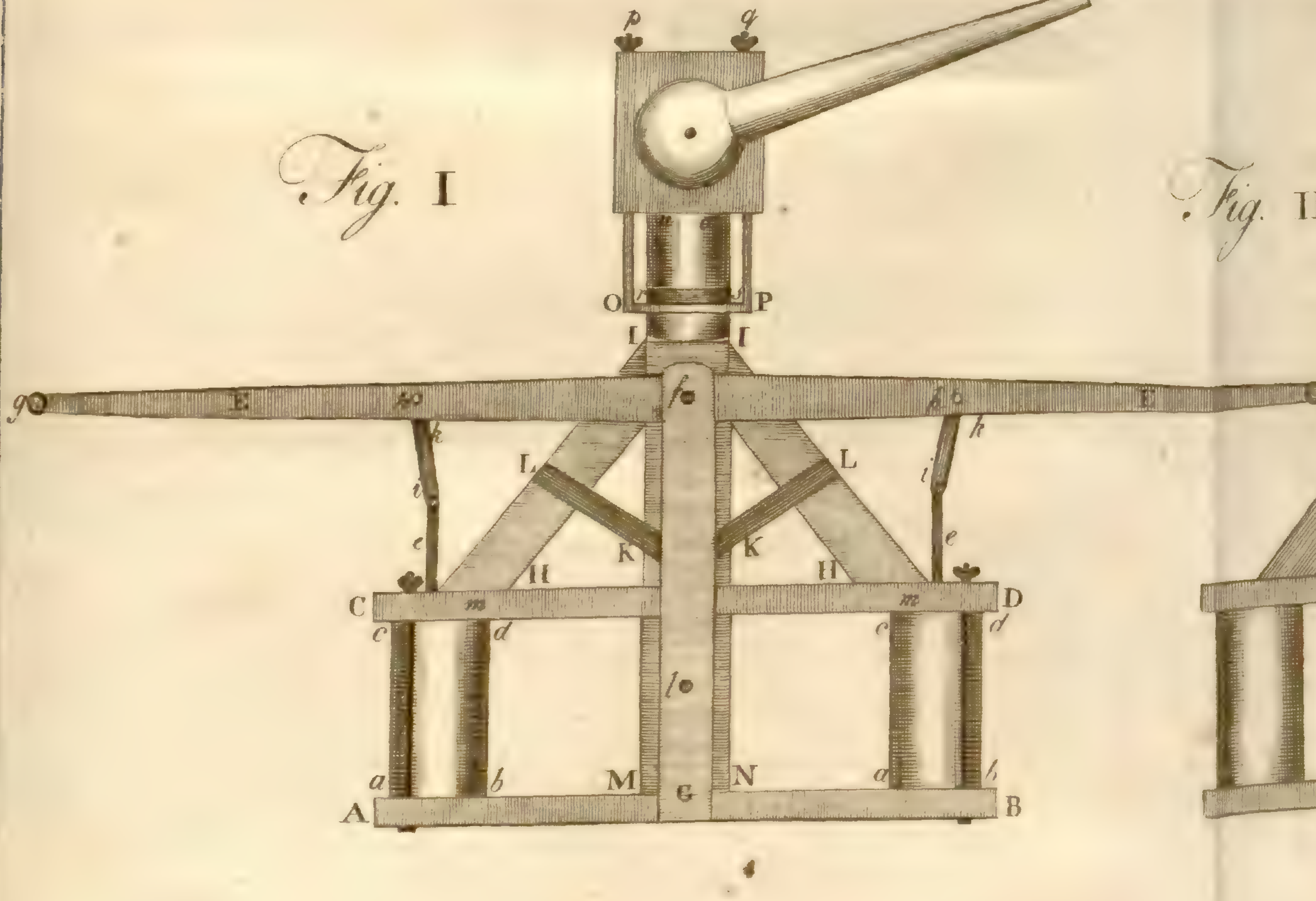


Fig. II

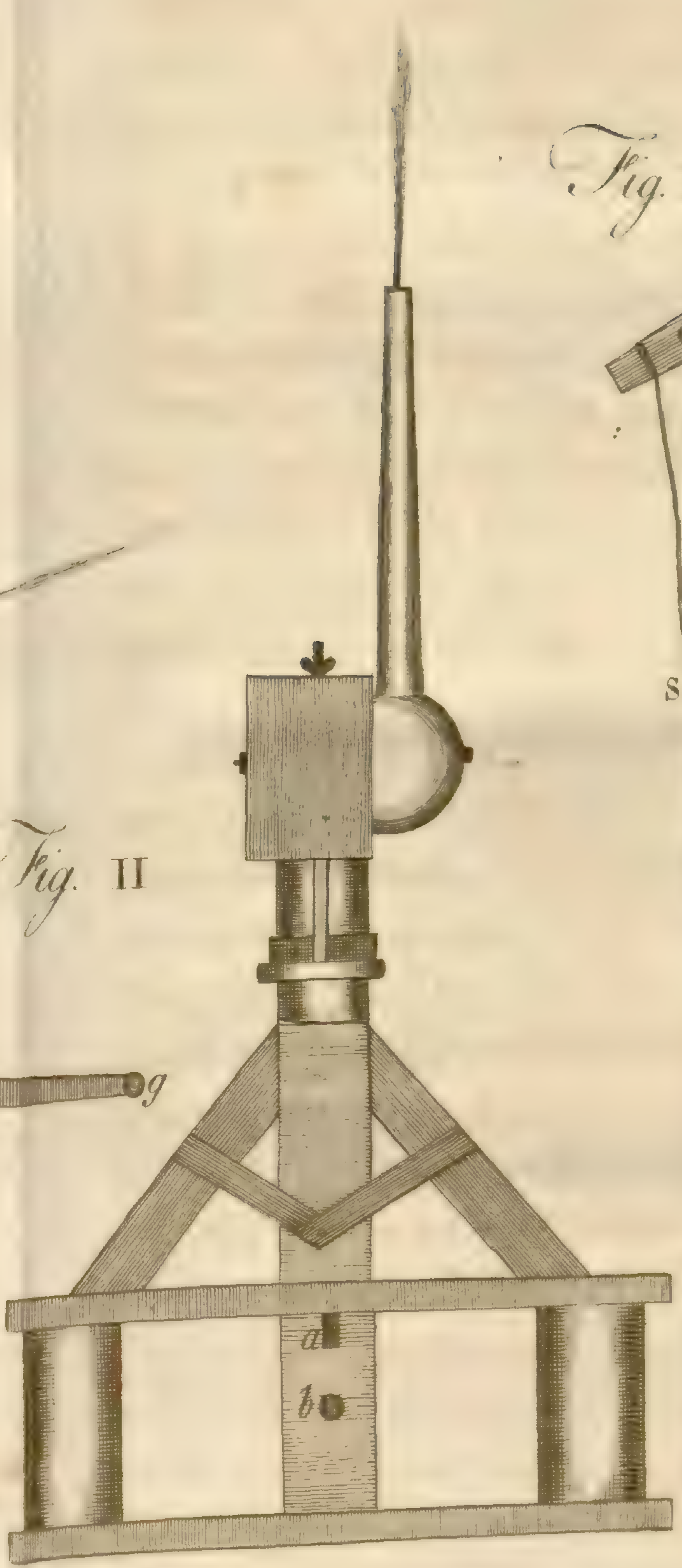


Fig. III

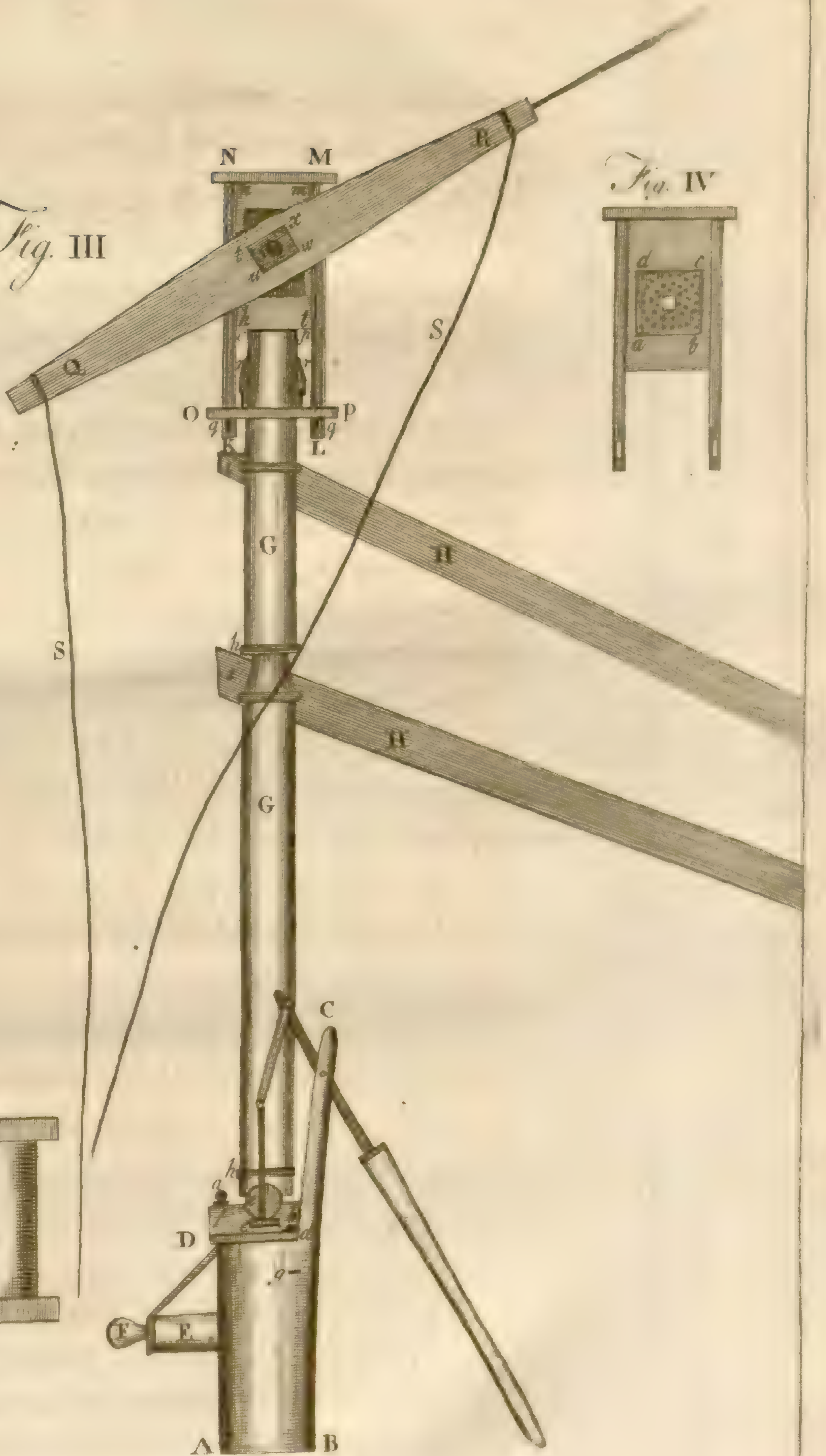


Fig. IV

XXIX. *Obſervations upon the Art of making Steel.* By the Reverend DANIEL LITTLE, *F. A. A.*

AS ſteel is an article of commerce, and of great uſe both in the arts, manufactures and huſbandry of every nation; and as we have the beſt of iron already manufactured in *America*, it is thought that the manufacturing of ſteel of a good quality, deſerves the attention and encouragement of thoſe who wiſh the welfare of the United States. What time I could redeem from other neceſſary buſineſs for ſeveral years paſt, has been employed in ſuch diſquiſitions and experiments, as might tend to facilitate the art of making ſteel, and others near akin to it.

Thoſe writers upon the ſubject which I have met with tell us, that the principal difference between iron and ſteel conſiſts in this, That the latter is combined with a greater quantity of phlogiſton than the former. Phlogiſton exiſts in all inflammable ſubſtances, and in ſome that are not inflammable. Charcoal, and the coals of bones, horns and hoofs of animals, have been uſed as fit ſubſtances for communicating phlogiſton to iron in making ſteel.

Steel is ſometimes made by fuſion of ore or pig-iron. The method is ſimilar to that of reducing pig-iron to malleable iron, with this difference, that as ſteel requires more phlogiſton than is neceſſary to iron, all the means muſt be made uſe of that are capable of introducing into the iron a great deal of phlogiſton; that is, by keeping it, while in fuſion, encompaſſed with an abundance of charcoal, &c.

The other method of making ſteel is by cementation, as it is called; that is, to convert bar-iron into ſteel; which is done by a cement made of thoſe ſubſtances which contain the greateſt quantity of phlogiſton. Put the bar-iron with this cement in-

to

to a veſſel that will bear a ſtrong fire ; lute on a cloſe cover, ſo as to prevent the cement taking flame and conſuming ; put the veſſel in a furnace where the bars may be kept red-hot till they are converted into ſteel, which will be in a longer or ſhorter time, according to the bigneſs of the bars, and the quantity of cement.

This latter method has chiefly engaged my attention, which method is pretty well known in ſome parts of *America*, and, for many years paſt, ſteel has been made by it in ſeveral of the United States. Yet, ſo far as I have been informed, it has generally been of an inferior quality, and very little uſed for edge tools, which I ſuppoſed could not ariſe from the quality of the iron, for we have the greateſt variety, and the beſt ſort, in many parts of the country. I then conjectured there might be found ſome other inflammable ſubſtance for a cement, which, if properly applied, would impregnate the iron with phlogiſton more advantageouſly. And, after many experiments, I found a particular marine plant that requires no other preparation but drying and pulverizing, and is commonly known by the name of rock-weed, or rock-ware, and is in the greateſt plenty on our rocky ſhores, coves, creeks and harbours of the ſea. In making ſome experiments upon this plant for a flux powder, a ſmall bit of iron was put into a crucible, and filled with the ſaid cement ; and, very unexpectedly, after it had been in a little more than a cherry heat for five or ſix hours, it was converted into ſteel, which gave me the firſt hint of its uſe in making ſteel ; ſince which I have had repeated experience of its excellency for the ſame purpoſe.

It needs no other preparation than to be cut off from the rocks with a ſcythe or ſickle, ſpread on the dry land 'till the rains have

waſhed

waſhed off the greater part of the ſea-ſalt, then dried and pulverized, then uſed as other cements are in making ſteel: or, inſtead of waſhing off the ſea-ſalt, it is better for ſome particular kinds of iron, to neutralize it by adding a fixed alkali.

To two parts of the plant well dried and pulverized, add one part of good wood-aſhes; mix together and moiſten the whole with water or rather urine to the conſiſtence of a very thick paſte.

It is well known that in every new art, and in perfecting old ones, many unforeſeen difficulties ariſe, and ſometimes conſiderable fortunes have been ſpent before the manufacturer or the public have been much benefited. And ſince honeſt but too credulous minds are often deceived by uncertain proof, and being willing to ſatisfy myſelf and others, by a better teſtimony than my own, I engaged a * gentleman of ability in the ſteel way for many years, whoſe furnace was complete and large, to make experiments upon my new diſcovered ſubſtance for a cement, who has written me, that "this ſteel is preferable to any he had ever made before." After all, I ſuppoſe different modes of preparation and further experiments will more fully aſcertain its utility.

The matter of the furnace muſt be of ſuch ſubſtances as will endure a ſtrong fire without fuſion. Aſbeſtos has been uſed to advantage, but a ſufficiency of it is not found in many places. Pipe-clay with one third part of pond-ſand, or, which is better, white ſtones free from grit, well burnt, and pulverized, inſtead of ſand, ſome ſpecies of ſlate and talc may be uſed with pipe-clay for furnaces and crucibles.

The cheſt or interior part of the furnace, for depoſiting the cement and bars of iron, muſt be covered ſo cloſe that the inflammable ſubſtance within may not be conſumed, but changed

* Col. *Eliot* of *Connecticut.*

like wood in a coal-kiln. The iron to be choſen of the beſt quality; its toughneſs and malleability are marks of choice.

Of the ore of iron.—This is often diſcovered by the magnet, but a great part of the beſt ore is that which the magnet will not attract, as *Linnæus* and *Macquer* juſtly obſerve. When in that ſtate it often reſembles the ruſt or calx of iron. Many tuns of which are brought to the iron-works in this neighbourhood, from which the beſt of iron is made. In its natural ſtate the beſt magnetic bar will not attract the ſmalleſt particle; but when roaſted with charcoal it becomes magnetic. This method of knowing whether any earth or ſtones contain the true ore of iron, may be of uſe to diſcover new bodies or beds of ore. The reduction of metals, or reſtoring them to their metalic ſtate from their calces, by combining them with the inflammable principle in the application of charcoal, may ſufficiently ſhow the efficacy of the above method for the diſcovery of the earth of iron in thoſe ſubſtances on which the magnet has no effect.

PART III.

MEDICAL PAPERS.

I. *An Account of the Horn-Distemper in Cattle, with Observations on that Disease. By the Hon.* COTTON TUFTS, *M.D. F.A.A. and M.S. In a letter to the Rev.* JOSEPH WILLARD, *Cor. Sec. A.A.*

BEASTS of the forest, guided by the dictates of nature, and uncontrouled by man in their food, air, exercise and rest, are seldom affected with any disease, whilst in almost all countries, the domestic kind, that are more immediately under the government of man, are subject to a variety.

Scarcely an instance in this country of reigning sickness among tame or wild beasts, has been noted by its historians; and it is within thirty years that we have heard much of epidemic diseases among either.

About twenty-five years past an epidemic distemper prevailed among dogs, and occasioned a great mortality. In 1768 horses were generally affected with a disorder of the head and throat, which proved fatal to many, and much injured the serviceableness of those that survived. About the year 1770, there were some instances of the *rabies canina*; happily but few dogs were affected, and but few persons were bit; their rage principally fell upon swine. In 1771, a mortal distemper prevailed among foxes, and greatly reduced their numbers: about this

 time

time, or not long after, a diſtemper appeared among neat cattle, which deſtroyed many, and has continued to this day. The diſtempers that befel theſe ſeveral kinds of animals, were ſaid not to have been known in the country before, more eſpecially that which has affected neat cattle, and which has generally been conſidered as a new diſeaſe: Some, however, have ſuppoſed it to be the ſame, which from time to time has made ravages in *Europe*, and more eſpecially in *England*. Whether it was ever known there is uncertain. It evidently differs from thoſe which *Engliſh* writers have mentioned as proving fatal to their cattle. The compilers of the complete body of huſbandry, republiſhed in 1768, make no mention of this diſorder, though they have treated largely of the diſorders of horn-cattle; thoſe that have been more eſpecially prevalent, and have proved mortal, they have deſcribed under the names of *gargil*, *garget* and *murrain*, and as attended with external ſwellings, inflammations, eruptions, and contagion, and add, that "the *murrain* is the diſtemper now, and of many late years, ſo fatal among the horn-cattle." In 1757, *Daniel Peter Layard*, M. D. F. R. S. publiſhed a particular account of the nature, cauſes and cure of the diſtemper then among the horn-cattle in *England*. He conſiders it as an eruptive diſeaſe, in the ſeveral ſtages, progreſs and effects of it, exactly the ſame with the ſmall-pox, and earneſtly recommends inoculation. None of the external ſwellings, eruptions or contagion, characteriſtic of theſe diſorders, and to which ſwine and ſheep, as well as neat cattle of all ages and kinds, are incident, are peculiar to this diſorder. It is commonly called the horn-diſtemper: Cows are more eſpecially ſubject to it; oxen but ſeldom,—bulls are ſaid to be exempt from it, alſo ſteers and heifers under three years of age. It is a diſeaſe that

affects

affects the internal substance of the horn, commonly called the pith, insensibly wastes it, and leaves the horn hollow. The pith is a spongy bone, whose cells are filled with an unctuous matter; it is furnished with a great number of small blood vessels, is overspread with a thin membrane, and appears to be united by suture to the bones of the head, and is projected to a point. In a healthy beast it fills up the cavity of the horn, the horn itself being a sheath or case giving firmness, and the whole serving as a weapon of defence.

This spongy bone, in the horn distemper, is sometimes partly and sometimes entirely wasted. The horn looses its natural heat, and a degree of coldness is evident upon handling it; when it is only in one horn, (which is often the case) a manifest difference between the one and the other will be perceived, and in all cases a want of natural heat will be apparent; wherever this is found, there is no room to doubt of the disorder's being present; yet it is seldom suspected without a particular acquaintance with other symptoms that commonly attend this distemper, and for want of knowing these, the farmer has often lost his cattle, not even suspecting the evil.

These symptoms are a dulness in the countenance of the beast, a sluggishness in moving, a heaviness of the eyes, a failure of appetite, an inclination to lay down, an aversion to rise, and, when accompanied with an inflammation of the brain, a giddiness and frequent tossing of the head; besides these the limbs are sometimes affected with stiffness like a rheumatism, and in cows the milk often fails, the udder is hard, and in almost all cases there is a sudden wasting of the flesh.

As soon as the disorder is discovered, an opening into the diseased horn should be immediately made, which may be done

with a twenty-penny-nail gimblet, in a part of the horn which might be ſuppoſed to be moſt favourable for a diſcharge; it is moſt prudent to bore, at firſt, two or three inches above the head; if it is found hollow, and the gimblet paſſes through to the oppoſite ſide without reſiſtance, and no blood diſcharges from the aperture, it may be beſt to bore ſtill lower, and as near the head as it ſhall be judged that the hollowneſs extends. This opening is a neceſſary meaſure, and often gives immediate relief. Care muſt be taken to keep it clear, as it is apt to be clogged by a thin fluid that gradually ouzes out and fills up the paſſage. Some have practiſed ſawing off the horn, but from the beſt obſervations it does not ſucceed better than boring.

In autumn, 1774, on a farm not far from my houſe, I had four cows ſeized with this diſtemper in the ſpace of a fortnight; the firſt, an old cow, was affected with ſtiffneſs in her hind parts, her milk failed, her udder was hard and ſwelled, her eyes heavy, and her fleſh ſuddenly waſted. My tenant requeſted me to view her, upon an apprehenſion that ſhe had met with ſome hurt. At this time the diſorder was not much known among us; fortunately a perſon feil in my way who had ſeen a ſimilar inſtance, and upon relating the caſe, he ſuggeſted that it was the horn diſtemper, and upon examining her horns, one of them was found to be cold, and was immediately bored with a gimblet, which paſſed through to the oppoſite ſide without reſiſtance, and no diſcharge followed; finding the horn hollow, I was led to think that the bones below were carious, and immediately made a mixture of rum and honey, with the addition of ſome tincture of myrrh and aloes, and ſyringed the horn; the injected liquor was ſoon diſcharged at her noſe, tinged with blood; this was repeated ſeveral times, daily, and the injected

liquor

liquor continued to run off through the nose for two or three days; at length it ceased to pass that way.—Emollient fomentations were applied to her bag—these were the only applications.—The cow in a few days shewed signs of recovery, but did not regain her flesh for several months. A second and third cow were taken ill; the disorder being early discovered, their horns bored and syringed several times, they soon recovered. A fourth cow, about four years old, was observed, in the morning, to have the disorder, her horns were bored and syringed, her tail* cut for the purpose of bleeding, and from suspicion of defect in it; by nine o'clock she was scarce able to stand, at noon she was unable to rise, her head was very hot, her eyes dull, and she groaned as if in great pain; towards night she appeared as if near expiring, her eyes were unmoved at being touched, and the lustre of them entirely gone, some degree of coldness, and a universal convulsion attended her; under these circumstances, I directed my tenant to take one ounce of powdered mustard-seed, to simmer it in a quart of milk, and add thereto one gill of molasses, the whole to be given immediately, afterwards to cover her over thick with straw,—this was soon done. In this state she was left in the evening; before morning she had escaped from her straw, and was feeding in the field. She recovered without any further application.

In the spring of 1779, another cow, of four years old, was seized; she was observed in the morning to refuse her food, her eyes were heavy, she hung down her head and manifested an unhealthy countenance; the disorder was suspected, her horns examined;

* Neat cattle are subject to a disorder commonly called the tail sickness, which is a wasting of the bony substance of the tail, and if not cut off or dilated as far as the defect reaches, often proves fatal. It frequently accompanies the horn distemper.

amined; one of them felt cold, was bored, found hollow, and ſyringed; through the day ſhe was giddy, toſſing her head backward and forward, frequently groaned as if in great pain, and upon rubbing her forehead ſhewed ſigns of eaſe, her ſtrength was not much diminiſhed, her natural evacuations by ſtool and urine were free; however, ſhe died the next morning; and, according to the information of my tenant, upon opening the body, the *viſcera* were all ſound, no mark of diſorder was ſeen there; but upon opening her head, the brains appeared of an unnatural colour, and, by his account, tending to a mortification.

From the number of cows ſeized with this diſtemper in the ſpace of a fortnight, as before mentioned, a ſuſpicion aroſe that the diſtemper was infectious; time, however, has ſhewn that it is not ſo, at leaſt in any great degree, for it frequently happens, that among many cattle herding together, one of them ſhall have the diſtemper and the other remain in perfect health.

It appears from the firſt recited caſe, that the injected liquor had a free paſſage from the horn to the noſe; yet, previous to the boring of the horn, there was no viſible diſcharge at the noſe of the waſted ſubſtance, or of any other matter, nor has there been in any other inſtance that I have heard of. As there appears no external diſcharge of the waſted bone, it muſt probably lodge in the cavities of the head, and, in proceſs of time, affect the brain; or the matter may be ſubtilized to a great degree, and be drawn into the circulations. It ſeems ſurpriſing that ſo large a portion of bone as that which fills up the horn ſhould be deſtroyed, and the beaſt manifeſt no more complaints than are commonly obſerved; for the whole ſubſtance is generally loſt, before the complaints riſe ſo high as to excite the notice of the farmer. To account for this, may it not be ſuppoſed,

posed, that the mortification or dissolution of the pith is attended with a degree of insensibility, and that the distress discovered does not exist in any great degree until the brain is in some measure affected, or the matter is absorbed, and injures the habit in general?

Air-bubbles are continually forming at the orifice, through which the thin fluid ouzes after the horn is bored. This indicates an internal fermentation, and it is not improbable that putrid matter of some kind or other may have given rise to it. The matter may at first be formed on the periosteum, and entering into the interstices of the bone, may dissolve the oily substance, and form a fluid so putrid and corrosive as to dissolve even the bone itself; upon this supposition, the air within becoming putrid and confined by the heat of the parts, will be largely expanded, from whence a great degree of compression upon the surrounding parts must ensue; its effects at first may be small, after a while greater; at first producing no great distress, after a while some pain, but not sufficient to produce such uneasy sensations as to be noticed; but when the bone is entirely wasted and the putrid air much increased, and the compression become great, the tender vessels of the head must feel the force of it; the humors also may be highly acrimonious, and produce a general irritation. But from that sensible relief that an opening into the horn gives the beast, it is more than probable that the distress discovered arises from compression, rather than from an effect produced on the blood and juices; for, in some instances, the beast is almost instantly relieved by making an opening into the horn.

The passing of liquors from the horn to the nose, as in the case first mentioned, may perhaps be considered as an objection against

against the compression supposed; but it is to be noted, that though there was a communication between the horn and the nose in this case, yet it does not appear that there was any in divers other instances, and in this also after several days.

From late observations I am led to conclude, that injections are in general unnecessary; that when the distemper is early discovered, no more is required than a proper opening into the horn, keeping it sufficiently clear for the admission of fresh air, the removal of the compression, and the discharge of floating matter. But when the distemper has communicated its effects to the brain, so as to produce a high degree of inflammation, it is much to be doubted whether any method will succeed.

II. *Case of a remarkably large Tumour, found in the Cavity of the Abdomen.* By Joshua Fisher, *F.A.A. and M.S.*

THE ſubject of the following memoir, was a woman of ſtrong habit, rather ſpare than groſs, and of an active diſpoſition. She lived in a married ſtate from early life, but never had a child; was not peculiarly ſubject to any diſorder, except ſome florid cutaneous eruptions, till at about the uſual time of life the *catamenia* ceaſed. Soon after that period ſhe became ſenſible of an unuſual fullneſs in the abdomen, which continued almoſt imperceptibly increaſing, without any diſagreeable ſymptoms, till ſhe was near ſixty years old, about two years before her death. She then complained of a pain in the left hypochondriac region, which became ſenſibly tumefied; the pain and diſtenſion from thence increaſed, and ſpread over the whole abdomen.

I firſt ſaw her between four and five months before her death; I found the abdomen very large and tenſe, eſpecially on the left ſide, which was the moſt painful: the veſſels in her head and arms, were full and turgid, while an inanition had taken place in the lower extremities, with a variety of ſymptoms ariſing from an unequal diſtribution of the circulating fluids and nervous influence. But the immediate cauſe of her principal complaints was an inflammation, which appeared to be ſeated forward of the *rectum*; although ſcarcely any part of the abdomen was exempt from attacks of the moſt excruciating pain at intervals, yet the lower and poſterior parts were principally affected; and while a ſuppuration was forming (which had probably taken place ſeveral times before I ſaw her) the pain darted a little backward and downward, and terminated in the

 rectum,

rectum, by which a quantity of bloody pus was, at length, discharged. Her bowels were generally conſtipated, and when the ſymptoms were the moſt ſevere, the diſcharge of urine was ſmall, and attended with pain.

The principal medicines that I made uſe of, were *hauſt. ſalin. Ol. Ricin.* with *anodynes p.r.n.* In the ſpace of a few weeks, the ſymptoms of inflammation diſappeared, the ſecretions and excretions became free, and by the uſe of the bark and gentle exerciſe, ſhe recovered a conſiderable degree of ſtrength, the ſymptoms ariſing merely from diſtenſion and compreſſion being very tolerable. This truce laſted about two months: a ſudden ſuppreſſion of perſpiration was followed by a return of her complaints with redoubled violence, and ſome paralytic ſymptoms. On the twelfth day of her relapſe, ſhe diſcharged a conſiderable quantity of purulent matter, intermixed with ſome blood and fœces, but without any relief, and ſhe died on the fourteenth. In her laſt ſtruggles, which were very violent, ſhe diſcharged (probably *per vaginam*) a quantity of darkiſh water, reſembling high-colour'd urine, amounting, by eſtimation, to at leaſt two gallons. This diſcharge conſiderably reduced the bulk of the abdomen, eſpecially of the left ſide.

The day after her death, I went about noon, with the Rev. Mr. *Cutler*, of *Ipſwich*, and Dr. *Spafford*, of *Beverly*, to open the body. We expected that it would not be buried till the day following, but to our great diſappointment, found it was to be interred the ſame afternoon: at length, however, we were allowed an hour to examine it.

On opening the abdomen, which now appeared about as large as in the laſt month of pregnancy, a preternatural ſubſtance preſented itſelf, ſituate a little more to the right ſide than to the

the left, and occupying nearly the whole cavity. After separating it from the contiguous parts, to all of which it firmly adhered, its general figure appeared to be that of a cone or pear; the lower part (supposing the body erect) being within the *pelvis*, was very nearly conical; the upper part was divided by two grooves, running in a right line from its basis, towards the apex; the one on its anterior, the other on its posterior side, dividing it into two lateral portions, and giving it the appearance of its having been formed by two globular bodies, compressed together. The posterior groove corresponded to the projection of the spine, to which it adhered; the anterior groove was wider, and the protuberances on each side somewhat larger. The basis lay above the kidneys, and the apex nearly low enough to form a tumour in perinæo: By cutting into it, it appeared to be an uniform schirrus of a cineritious colour, with vessels, or rather perforations interspersed, for conveying the circulating fluids. From its situation, connections and figure, it appeared to have originated in both the *ovaria*; the two schirrosities in process of time united, and meeting with the least resistance from below, extended into the *pelvis* 'till the cavity was compleatly filled. It weighed upwards of ten pounds and a quarter, averdupois weight. We made some observations on the neighbouring viscera, but for want of time, they were unavoidably very imperfect.

The *vesica urinaria* was moderately distended with urine, forming a tumour over the *ossa pubis*, the neck being compressed between the *pubis* and the schirrus; its whole anterior surface was firmly attached to the *peritoneum*, and the posterior to the schirrus, except a small portion in the middle of it, which adhered to the *uterus*, where that viscus intervened. The ure-

ters, for the ſpace of two or three inches, ſeemed to lie looſe, and contained a ſmall quantity of urine; their coats were thin and conſiderably diſtended. They then entered upon the ſchirrus, one on each ſide, involved in a membrane hereafter mentioned, running obliquely forward and downward, till they entered the bladder; after they were connected to the ſchirrus, their appearance was the reverſe of the former: to enable them to take this circuit, they had been greatly extended, and their diameters were exceedingly ſmall. The *uterus* was extended in a right line upon the ſchirrus from its baſis, to which the *fundus uteri* adhered, through the anterior groove, almoſt to its apex, continuing about an inch and a quarter wide, and firmly attached through its whole length. Its coats appeared in a natural ſtate, except that they were thinner by reaſon of their extenſion.

The appearance of the *tubæ fallopianæ* was ſo unnatural that they were ſcarcely diſtinguiſhable; we found a membranous covering cloſely embracing the baſis, the anterior, and lateral ſides of the ſchirrus, extending downward nearly to the *pelvis*; and by its upper and lateral edges adhering to the ſchirrus, it ſeemed to ariſe from the *uterus*, which was ſituated in the middle of it, and its external membrane was a continuation of the external membrane of the *uterus*. Through this expanſion on the baſis of the ſchirrus were ſeveral ſmooth but irregular apertures, of about two inches circumference, through which the baſis of the ſchirrus appeared; it was here about a quarter of an inch thick, its fibres fleſhy and variouſly convolved, the lower part of it was much thinner and purely membranous. That part of this tegument which was ſpread upon and near the baſis, appeared to be formed by a diſtenſion of the fallopian tubes included in the

peritoneum

peritoneum or common membrane of the abdomen, and the remainder of it by an expanſion of thoſe duplicatures of the ſame membrane, uſually termed *ligamenta lata.*

On the backſide, the ſchirrus was attached to the *aorta, vena cava,* &c.—to the *rectum,* which was protruded to the right ſide of the ſpine, it adhered for the ſpace of ſeven or eight inches: Near the baſis, the adheſion was ſtrong; but a little lower, the connecting membrane contained a quantity of grumous blood, appeared putrid, and in ſome places was deſtroyed.

We wiſhed to have aſcertained the ſource of the water which the patient diſcharged at the time of her death: by the appearance of the viſcera there had been none diffuſed in the cavity of the abdomen; and, from the circumſtances above mentioned, it muſt have been contained in the left *hypochondrium*: In removing the ſchirrus, we found a membrane (a ſac to appearance) adhering to it, which we cut through, and ſuppoſed to be an empty hydropic cyſt; but the ſchirrus at that inſtant engroſſed our attention; and people ſoon collecting to attend the funeral, all further examination was prevented.

We obſerved nothing extraordinary in any of the other viſcera; the *omentum,* as is uſual in tabid caſes, was nearly waſted, and a number of the meſenteric glands were enlarged and indurated.

III. *Remarks on the Effects of stagnant Air.* By EBENEZER BEARDSLEY, *Surgeon of the 22d Regiment of the* American *Army, in the Campaign of* 1776.

ABOUT the beginning of April, 1776, the *American* army, under the command of his Excellency General *Washington*, marched from *Boston* for *New-York*, at which place they arrived near the middle of the month. The sick and invalids having been left behind, the whole army were in perfect health. They took up their quarters in the barracks and houses of the citizens, 'till about the first of May, when they all went into tents, except the 22d regiment, under the command of Colonel *Samuel Wyllys*, who, for want of tents, continued in their quarters in *Smith-Street*. This regiment was very healthy until about the middle of the month, when upwards of one hundred of the men were taken down with the dysentery in the space of one week. Such a sudden invasion of this formidable disease alarmed me greatly. As I found upon enquiry that there was not a single dysenteric patient besides, in the whole army, I concluded that the disease arose from some cause peculiar to the city: but after a careful enquiry, I could not find that there was a single inhabitant in the whole city that was sick with the distemper. Those who lived in the same street, and many of them in the same houses with us, were entirely free from this, or indeed any other disease. For several days I was much perplexed, and greatly at a loss as to the cause. At length I observed that not only the citizens with whom we lived were free from the disease, but that some whole companies of the same regiment had nothing of it. This led me to consider more minutely the situation and circumstances of those who were sick; all of whom, I found, lived either in

low underground rooms, or else in garrets, so situated as not to admit of a free circulation of air. The rooms were also considerably less in proportion to the number of men than usual. Struck with these discoveries, I concluded at once, that the disease arose from a confined stagnant air; deprived by this means of its natural elasticity, and loaded with putrid *effluvia* from the bodies of the unhappy people who lived in it. Having communicated my discoveries to the Colonel, I requested that the men, (both sick and well) might be removed out of those rooms into such as were more airy and capacious. This measure was attended with the most salutary consequences. Those who were sick recovered in a short time, except one or two that died; and no more being seized with the disease, in a few weeks the regiment became entirely healthy. There was nothing peculiar in the symptoms which attended the disease, except, as is usual in vernal distempers, that there was a greater degree of inflamation than commonly attends autumnal disorders of the same *genus*. The discovery of this singular instance of the pernicious effects of confined stagnant air, was of great use to me in the course of the campaign. In the months of July and August, the dysentery, bilious and other fevers of the putrid kind, became very rife both in the army and country. Great pains were taken to procure for our men who were sick with any of those disorders, large rooms, and to have them well ventilated. Yet, under these circumstances, I frequently observed, that (*cæteris paribus*) the sick who lay in and near the corners of the rooms, were handled much more severely than those which lay in the middle of them.

I do not remember to have met with this observation before, but it is undoubtedly of great importance in the treatment of dysenteries and other putrid diseases.

IV. *A remarkable Case of Gun Shot Wound. Communicatd in a Letter from* BARNABAS BINNEY, *Hospital Physician, and Surgeon in the* American *Army, in* 1782, *to the Honorable* BENJAMIN LINCOLN, *Esq; F. A. A.*

ON April 9, 1782, *David Beveridge*, a seaman, belonging to the sloop of war General *Monk*, was brought into the military hospital at this place, having been wounded the day before. He was a lad of about nineteen years of age, and in a good state of health, at the time of the action between the said ship and the *Hyder-Ally.* In that action he was in the main-top of the *Monk*, when he received a musket-ball in his belly from one of the marines on the quarter-deck of the *Hyder-Ally*, then within fifteen yards of the *Monk.* The ball entered his belly about two inches above his left groin, and within an inch of the anterior edge of the left *ilium*, passing out two inches on the right of the spine between the two inferior true ribs, just touching the cartilage of the inferior angle of the right *scapula.* When he came into the hospital he had bled much, was very weak and cold, had a faultring voice, a cadaverous countenance, and a constant hiccup, while his fœces passed freely out of the wound in his belly. In this deplorable condition, where neither art nor nature could promise any permanent relief, the only dictate of humanity was to smooth the path of death. Being also in great pain, I advised him to take a glass of *Madeira* wine, with twenty or thirty drops of *liquid. laudan.* in it, as often as necessary. He accordingly began, and continued this practice 'till the thirteenth, finding constant relief from it. He took no kind of sustenance all this time excepting wine whey, never having any kind of discharge *ab ano* from the moment he was wounded, but constantly squirting with considerable force

what

what fœces he had, through the wound in his belly. On the fourteenth he had a common glyſter adminiſtered, the greateſt part of which alſo came out at the wound, the remainder coming as it went, *ab ano*, without bringing any fœces. From the fourteenth to the eighteenth he took conſiderable quantities of gruel and whey, with a little wine occaſionally, having no inteſtinal diſcharge whatever but what was made through the wound in his belly. On the eighteenth, as his ſtrength was much increaſed, and as the wounds were conſiderably contracted, and looked well, I ordered another injection to be adminiſtered gently, when, for the firſt time, in eleven days he had a natural ſtool. From this time he had no further diſcharge of fœces through his wound; his excretions became as regular and as natural as ever they were; his wounds ſuppurated and healed kindly; his ſtrength returned; and he was exchanged nearly as well as ever, on the thirtieth.

That the ball had paſſed through the colon is obvious, from the diſcharge of perfect fœces and of the injection adminiſtered, *ab ano*. That his life depended upon our not meddling with the wound, and upon keeping him quiet and eaſy, is alſo plain; as the leaſt removal of the orifice in the inteſtine from the orifice through the abdomen, which were ſo happily oppoſed to each other, muſt have been attended with a fatal diſcharge of the fœces into the abdomen. That the diaphragm and lungs were perforated is plain, from the courſe of the ball, and his profuſe hæmoptoe. That Surgeons may be too officious, as well as too tardy; and that where they are not certain of the utility of their operations, they had better leave even the moſt deſperate diſorders to the management of nature, ever provident, and generally adequate, are points remarkably enforced in this particular caſe.

V. *A Bill of Mortality for the Town of* Salem, *for the Year* 1782. *By* EDWARD AUGUSTUS HOLYOKE, *M. D. F. A. A. and M. S. In a Letter to Mr.* CALEB GANNETT, *Rec. Sec. A. A.*

SIR,

I Herewith ſend you a bill of mortality, for the town of *Salem*, for the laſt year, which, although not ſo accurate as I could wiſh, may yet perhaps be worth communicating to the Academy; heartily wiſhing the public might be favoured with more correct bills of a like kind, from a variety of towns, of ſimilar, and of different ſituations, for a courſe of years ſucceſſively, as they would certainly afford the beſt means of judging of the ſtate of population, a matter of real uſe and of great curioſity.

Salem is a ſea-port town, ſituated in the 42d degree of N. Lat. on *Maſſachuſetts-Bay*, about five leagues to the weſtward of *Cape-Ann*, and about as far north-eaſtward from *Boſton*; where a conſiderable trade is carried on both with *Europe* and the *Weſt-Indies*. That part of it which is ſettled thickeſt, is moſtly a peninſula lying between two ſalt water rivers. The ground is flat and low, being ſcarcely more than twenty, or twenty-four feet above the level of the ſea, at high water, any where, and in moſt places not near ſo much; and excepting a hill in the north-weſt, and another to the weſtward, neither of them very high, there are no eminences to interrupt the free courſe of the winds. The ſoil is in general light, dry and ſandy, and quite free from any marſhes or collections of ſtagnant waters. The water of the wells, which are very numerous, is pretty good, that of many ſo pure as to bear ſoap well; though, I think, our tea-kettles are generally covered on the inſide with a ſtony cruſt.

The

The inhabitants are not ſubject to any endemic diſorders; though, thirty or forty years ago, hyſteric and nervous complaints, are reputed to have been more than commonly riſe here; at preſent, I believe we are as exempt from ſuch maladies as the neighbouring towns.

In the following bill the number of the *dead*, I believe, is pretty accurate; the *ages* of the deceaſed in general, and the *month* they died in, are tolerably aſcertained; but as to the liſt of *diſeaſes*, I cannot be anſwerable for a conſiderable part of it, as the beſt account I could procure of the diſeaſe is ſometimes taken from the ſextons, the reports of nurſes or perſons about the ſick; and how uncertain *that* muſt be, I need not ſay, when even phyſicians themſelves are often at a loſs how to claſs the diſeaſes of their patients, with the preciſion they would wiſh; and in ſeveral inſtances I have not been able to procure any account of the diſeaſe at all: I thought it better, however, to give a bill of that ſort, imperfect as it is, than to ſuppreſs it entirely. As to the *births*, I believe the account is as compleat as can be expected, conſidering from whom we are obliged to collect the greateſt part of it; and, I ſuppoſe, approaches much nearer to the number of perſons actually born, than accounts of chriſtenings ever can, in any country where there is a general religious toleration; indeed, in a town where there are various religious ſects, ſome of which never adminiſter baptiſm at all, and others who never adminiſter it but to adults, which is our caſe, births can never be tolerably gueſſed at from an account of chriſtenings. Theſe however are not neglected, the gentlemen of the clergy having been ſo obliging as to furniſh me with a compleat liſt of their ſeveral baptiſms; from the ſame hands too, and from the Juſtices of the Peace, who by our laws are quali-

fied to marry, I am favoured with the number of couples married. The number of rateable polls, &c. I have from the aſſeſſor's liſt. I would further obſerve, that the year 1782, taking it throughout, was more ſickly than ordinary, and I have great reaſon to think that we have not had ſo great a mortality, ſince the year 1773, which is the more remarkable, as no epidemic diſorder has been uncommonly prevalent.

I ſhould have been glad to have procured a more particular bill, as well as a more accurate one, but found it impracticable.

I am &c.

E. A. HOLYOKE.

Mr. Caleb Gannett.

A Bill of Mortality for *Salem*, for the Year M,DCC,LXXXII.

General Bill.	
Deaths	175
Births	317
Baptiſms	152
Marriages	70
Rateable polls, *i.e.* males, from 16 years old and upwards, reſident in the town,	897
Tranſient perſons—males,	200
Monthly Bill.	
January, died	21
February	11
March	9
April	12
May	8
June	11
July	11
Auguſt	12
September	35
October	22
November	10
December	13
	175

Bill of Ages.			
Still-born			6
Within the month			6
Between 1 mon. and		1 year	30
1 year	and	2	20
2	and	5	2
5	and	10	7
10	and	15	3
15	and	20	6
20	and	25	5
25	and	30	7
30	and	40	24
40	and	50	10
50	and	60	7
60	and	70	2
70	and	80	7
80	and	90	6
Ages unknown, of children chiefly,			27
			175

Bill of Diseases.

Angina	3
Aphthæ	2
Apoplexy	2
Afcites	3
Afthma	1
Atrophy	5
Cachexy	7
Chin-Cough, combined with Dyfentery and Cholera Dyfenterica	7
Cholera Morbus	1
Cholera Dyfenterica	20
Coeliaca	1
Complicated Cafe	1
Confumption	4
Convulfion	7
Diarrhœa	3
Dyfentery	6
Empyema	1
Eryfipelas	1
Fevers	8
Catarrhal	4
Hofpital	3
Pleuritic	2
Peripneumonic	3
Putrid	1
Nervous	2
Rheumatic	1
Hydrocephalus Internus	4
Hypochondriacifm	1
Lethargy	2
Lientery	1
Old Age	7
Over-Eating	1
Paralytic	6
Phthifis Pulmonalis	13
Ricketts	2
Ulcers finuous	1
Vomiting	1
Worms	1
Suddenly	5
New-born	6
Still-born	6
Cafualties 7, viz.	
Burnt	3
Drowned	1
Frozen	1
Over-laid	1
Scalded	1
Difeafes unknown of	13
	175

A Bill of Mortality for *Salem*, for the Year M,DCC,LXXXIII.

General Bill.

Deaths	189
Births, about	385
Baptifms { Boys 80, Girls 78 }	158
Marriages, about	84
Rateable polls, *i. e.* males, from 16 years old and upwards	1000
Number of inhabitants eftimated at about	9000

Monthly Bill.

January	5
February	9
March	9
April	11
May } Meafles were epidemic	33
June } Meafles were epidemic	24
July	14
Auguft	17
September	25
October	12

November

November	14
December	16
	189

Bill of Ages.

Still-born			14
Within the month			11
Between 1 mon.	and	1 year	27
1 year	and	2	29
2	and	5	28
5	and	10	12
10	and	15	3
15	and	20	2
20	and	25	8
25	and	30	8
30	and	40	9
40	and	50	8
50	and	60	7
60	and	70	6
70	and	80	6
80	and	90	2
Ages unknown of			9
			189

Bill of Diseases.

Anasarca after Scarlet Fever	4
Angina	1
Apoplexy	3
Ascites	1
Asthma	2
Atrophy	4
Cachexy	2
Cancer	1
Child-birth	1
Cholera Dysenterica	8
Coeliaca	3
Complication	3
Consumption	5
Convulsions	8
Cynanche-maligna	5
Dysentery	6
Epilepsy	4
Empyema	1
Fevers	1
From dentition	1
Pleuritic	1
Peripneumonic	5
Rheumatic	2
Scarlet	2
Synochus	5
From worms	1
Hard-Drinking	1
Hæmoptosis	1
Head mould-shot	1
Hydrocephalus Internus	1
Inflamed Intestines	1
Imperforate Anus	1
Lientery	1
Lock'd-Jaw	1
Measles	16
After Measles, of Angina	2
Fever	3
Consumption	2
Dysentery	2
Peripneumony	7
Sphacelus	1
Synochus	1
Old Age	5
Oppression	1
Paralytic	1
Phthisis Pulmonalis	13
Scrophulous Ulcers	2
Suppressio Urinæ	1
Spasm at Stomach	1
Vomica	1
Vomiting	2
Worms	3
New-born, *i. e.* within the month	11
Still-born	14
Suddenly	2
Shot dead	1
Diseases unknown of	10
	189

VI. *A History of a large Tumour, in the Region of the Abdomen, containing Hair.* By JOHN WARREN, *Esq; F. A. A. and M. S. and Professor of Anatomy and Surgery in the University of* Cambridge.

AN aversion to the making of large incisions, into such tumours as have appeared to have been seated within the cavity of the abdomen, has perhaps often been the reason, why those of them, which have happened to contain a substance less fluid than pus, have either induced a hectic, from a copious absorption of the thinner and more acrid parts; or, have speedily been followed by a fatal termination. The following history, may in some measure evince the safety of such large and free openings, in cases of this kind; but the facts contained in it, may also admit of an application to the purpose of explaining certain *phenomena* in the *animal œconomy*.

The production of hair in the human body, though it has often been the subject of accurate examination, and ingenious speculation, has perhaps never yet been satisfactorily accounted for; or to say the least, the solution is still destitute of that support and conviction, which in most other physiological inquiries, have so happily been attained.

Admitting the position, that many, if not all the interior parts of the body, are furnished with the necessary fluids for the growth of this substance, an accurate attention to the circumstances under which it is really produced, and to the nature of the parts in which it is most frequently found, must undoubtedly afford very considerable light on the subject; and from a large number of such facts, carefully and judiciously collected, it

it is not improbable that every doubt and difficulty, attending the inveſtigation, may be entirely removed.

Z—— H——, a negro woman, about thirty-two years of age, early in the year 1783, applied for medical aſſiſtance, in a caſe of a ſwelling in the abdomen, which had become extremely painful, and which began to be attended with very threatening ſymptoms. On examination, a very large tumour was found ſeated chiefly on the left ſide, occupying the whole ſpace between the left *os ilium* and the left inferior ribs, and extending over to the right of the *umbilical region*, pointing a little to the left ſide of the navel, conſiderably hard, and extremely ſenſible. Upon inquiry into the origin of the tumour, it appeared, that the patient had firſt complained of pain in the left groin, and a general enlargement of the abdomen, immediately after delivery of her third child: This gradually increaſed after two ſucceſſive labours, and ſince the birth of her laſt child, now about twelve years of age, had been almoſt conſtantly painful, though by no means in a very diſtreſſing degree, until about three weeks prior to her application for advice. At this period her complaints were greatly exaſperated, in conſequence of catching cold at the time of the catamenial evacuation, by which a total ſuppreſſion was induced. The common diſcutient topical applications were immediately made uſe of; the uſual methods were employed to renew the diſcharge; but all to no purpoſe. The ſwelling conſtantly increaſed for about three weeks, when an evident tendency to ſuppuration being perceived, the method of cure was immediately altered from a diſcutient to a ſuppurative proceſs. In about two weeks, a fluctuation was perceptible, and at the end of two more, an opening into the cavity of the tumour was determined upon.

An

An extenſive inciſion was accordingly made through the *rectus* muſcle, at a ſufficient diſtance from the uſual courſe of the *epigaſtric* artery to avoid all danger of wounding it, and about a pint of watery matter immediately iſſued through the orifice; after which about the ſame quantity of pure pus was diſcharged.

On introducing two or three fingers into the cavity, a quantity of ſoft ſubſtance was felt within it, much about the conſiſtency of ſoft ſoap. I immediately made uſe of a table-ſpoon, as the moſt convenient inſtrument that could be readily procured for extracting it, and about a pound of it was at this time obtained; after which, as a degree of faintneſs began to enſue, the wound was dreſſed, and the patient placed in her bed, in a proper ſituation for admitting of a free diſcharge of any fluid that might ſtill be retained.

At the three or four ſucceeding dreſſings, a portion of the ſame ſubſtance was taken out, till the whole being extracted, it amounted to the quantity of about four pounds.

At each dreſſing, the matter was particularly examined, and was found to contain a large quantity of ſhort hair or wool, about three quarters of an inch long, uniformly mixed with it, as is ſeen in the ſpecimen herewith preſented for the inſpection of the Academy.

In each hair was diſcoverable by the naked eye, a bulbous root, and a pointed extremity, both perfectly ſimilar to what is ſeen in an intire hair produced naturally in other parts of the body. After the removal of the whole ſubſtance, the hand was paſſed into and round the cavity in ſearch of bone, or any other foreign body which might be contained within it; but though ſome of the gentlemen preſent, on ſuppoſition of an *extra-uterine fœtus*, expected to have found the former, yet nothing of either

either could be felt, though every part was fairly acceſſible. From this examination, it evidently appeared, that the matter extracted had been contained in a ſac which firmly adhered to the *peritonæum*, a circumſtance, I believe, generally attendant on ſuppurations in the viſcera of the abdomen, as the natural conſequence of previous inflammation.

On being expoſed to the heat of the fire in an open veſſel, it emitted a ſtrong urinous ſmell, and was attended in other reſpects with moſt of the appearances uſually exhibited in the broiling of animal ſubſtances. The action of flame produced a ſmart and continued decrepitation of the ſalt contained in it, until the whole was reduced to a ſimple coal; but no ſigns of inflammability, or the preſence of any oily ſubſtance, were perceptible. When boiled, the water made uſe of in the proceſs was very little changed as to its ſenſible properties; but after ſtanding ſome time in a veſſel to cool, it depoſited a ſediment which was ſuſpected to be an alkaline ſalt, and which accordingly readily fermented with the vitriolic acid.

The patient, from the uſe of the bark, ſuperficial dreſſings, and a reſtorative diet, was, in about three months, enabled to enter upon her uſual employment, which was buſineſs of the moſt laborious kind. She had during her illneſs been much reduced, and for ſome time continued in an emaciated ſtate, yet ſhe now enjoys perfect health, and has become moderately corpulent. The catamenial evacuation has been regularly performed; but no ſigns of pregnancy have ever appeared, though before her ſickneſs, ſhe had borne children uncommonly faſt.

Many of the practitioners in the town of *Boſton* were called in to viſit the patient, and various were the conjectures upon the

nature

nature of the caſe. The abſence of all the uſual ſigns of pregnancy, except at thoſe periods which regularly preceded the reſpective deliveries abovementioned, is a ſtrong argument againſt the hypotheſis of an *extra-uterine fœtus*; and it ſhould ſeem by no means admiſſible, that the bones ſhould have been ſo perfectly diſſolved as to have formed with the muſcular, and other ſoft parts of a fœtus, one uniform and apparently homogeneous maſs of matter. Are we not authorized, from the general complexion of the caſe, particularly from the pain in the groin of the affected ſide, to pronounce the *ovarium* to have been the ſuffering part? The attachment of the *ligamentum rotundum* of the *uterus* to the adipoſe ſubſtance in the groin, ſeems to point out, either the *uterus*, or ſome other part connected with it, as the ſeat of the diſorder.

A diſeaſed *ovarium* may eaſily be conceived to acquire a ſize too great to admit of it's being contained in the *pelvis*, and from its elevation in the abdominal region, the *uterus* itſelf might alſo be raiſed, and a diſtention of the ligament thereby be produced. But it is farther probable, that from an immediate adheſion of the *ovarium* to the neighbouring part of the *uterus*, the inflammation with which thoſe parts might be affected, would extend to the ligament itſelf; the former cauſe operating in conjunction with this, would ſufficiently account for the pain in the groin of the affected ſide; and the application of this reaſoning in the above inſtance, together with the other facts contained in the hiſtory, might enable us, without much difficulty, to form a pretty ſure diagnoſis of the diſeaſe.

VII. *Experiments on the Waters of* Bofton. *By* J. FERON. *Surgeon-Major of his Moft Chriftian Majefty's Squadron, under M. de* TERNAY's *Command in* North-America, *and of his Majefty's Marine Hofpitals at* Bofton *and in* Rhode-Ifland, *F. M. S.*

WATER, a tranfparent, colourlefs, infipid body, commonly fluid, being part of the elementary compofition of all bodies, excepting metals, and fo effential to the exiftenee and prefervation of thofe into whofe compofition it enters, ought to be an object of careful attention.

That water which is a part of the elementary compofition of bodies is pure; if it was equally pure in the different repofitories where we find it, it would need no analyfis, it would every where produce the fame invariable effects, for the purpofes of animal and vegetable life, as well as in the various ufes to which it is daily applied; but as it is capable of diffolving many other fubftances, and of retaining them diffolved or fufpended, we feldom find it pure; it is always, more or lefs, loaded with foreign materials. These

Effais fur la Nature des Eaux de Bofton. *Par* J. FERON, *Chirurgien-Major de l'Efcadre de fa Majefté tres Chretienne, fous les Ordres de M. de* TERNAY *dans le Nord de l'*Amerique, *et de l'Hôpital de Marine de fa Majefté a* Bofton *et a* Rhode-Ifland, *M. S. M.*

L'EAU ce corps diaphane, infipide, fans couleur, ordinairement fluide, élément de tous les corps, exceptés les metaux, fi effentiel a l'exiftance et a la confervation des êtres dont il fait partie, doit etre un object digne de la plus grande attention.

L'eau qui entre comme élément dans la compofition des corps eft pure, fi elle etoit telle dans les differens endroits où elle fe rencontre, elle n'auroit pas befoin d'analife, elle produiroit partout un effet conftant, foit pour l'ufage animal ou vegetal, foit pour les differens ufages auxquels on l'employe journellement, mais comme ce fluide eft fufceptible de diffoudre diverfes fubftances, et de les tenir diffoutes ou fufpendues, on le trouve rarement pur, il eft toujours plus ou moins chargé de matieres etrangeres. Ces matieres different en raifon des endroits par où l'eau paffe ou fejourne,

These materials differ according to the places through which the water paſſes, or in which it is collected, in ſuch manner that it may be impregnated with one or many foreign principles which change its qualities, and render it in general prejudicial to health, and unfit for artificial uſes, though, indeed, in ſome caſes, they are favourable to both. Thus every one knows the efficacy of certain mineral waters in diſeaſes, and the utility of the waters of certain rivers and lakes for the uſe of dyers; for inſtance, the advantage of mixing the waters of the *Rhone* and *Saone*, at *Lion*, for dying black, the water of the *Saone* alone for crimſon, deep ſcarlet, cherry colour and violet, while thoſe of the *Rhone* alone are prefered for white, green, grey, yellow, &c. the river of *Gobelins*, at *Paris*, for ſcarlet, and others for different colours. Many of theſe diſcoveries are the reſult of accident; for others we are indebted to analytical inveſtigation. The analyſis of water then, is an object of importance, both to medicine and the mechanic arts.

I.

ſejourne, deſorte qu'elle peut 'tre charg'e d'une ou pluſieures ſubſtances étrangeres a ſa na ure, qui álterent ſes qual't s, et la rendent en g neral pr judiciable a la ſante et aux arts quoique dans certains cas elles les favoriſent; en effet perſonne n'ignore les bons effets de certaines eaux mineralles dans pluſieurs maladies, et de l'utilité qu'on tire, de celles de quelques lacs ou rivieres, pour les teintures, tel qúa Lion, les eaux du Rhône melees avec celles de la Saône pour le noir, l'eau de la Saône feule pour le cramoiſi, le ponceau, le ceriſe, le violet, & les eaux du Rhône ſeul font pr ferr es, pour le blanc, le vert, le gris, le jaune, &c. la riviere des Gobelins a Paris pour la couleur écarlate, ainſi que d'autres pour differentes couleurs; pluſieurs de ces connoiſſances ſont dues au hazard, mais on eſt redevable d'un grand nombre aux analiſes. L'analiſe des eaux ſemble donc etre un object qui merite l'attention du medicin et de l'artiſté.

Je ne promets pas de remplir la tâche que préſente un travail auſſi grand; j'expoſerai ſeulement les diverſes experiences que j'ai fait, et leur réſultats, avec autant de circonſpection

I do not engage to enter at large into a work ſo extenſive, I ſhall only relate the experiments I have made, and the reſult of them, with the neceſſary preciſion; and on the iſſue of theſe experiments, I ſhall form a determination of the qualities of the waters of *Boſton*.

Sea water does not every where furniſh the ſame reſiduum on evaporation. At *Boſton* the reſult was as follows:

A pint* of water taken up at the head of *Long-Wharf*, left upon evaporation 6 drachms† 40 grains; this reſiduum being diſſolved in diſtilled water and filtered, left 6 grains of calcareous earth on the filtre; the filtrated ſolution being evaporated, left 5 drachms 2 ſcruples of ſea ſalt, with an alkaline baſis; from 40 to 47 grains of ſea ſalt, with the terrene baſis, or *ſal. cathart. amar.* and a ſmall quantity of oil.

Pump water being in general uſe, particularly engaged my attention; it is more or leſs charged with heterogeneous parts in proportion

* *The pint was equal to an Engliſh quart.*

† *The Drachm mentioned contains 72 grains.*

circonſpection que la nature du travail exige, ces réſultats me ſerviront de guide pour former un jugement ſur la nature des eaux de *Boſton*.

Les eaux de la mer ne fourniſſant pas partout le même réſidu par l'évaporation, je vais mentionner ce qu'elles mo'nt donné à *Boſton*.

Une pinte * d'eau priſe à la tête du *Long-Wharf*, m'a fourni apres l'évaporation ſix gros † et quarante grains de reſidu, les quels ayant été diſſous dans l'eau diſtilleé a laiſſé ſur le filtre ſix grains de terre calcaire, l'eau évaporée a rendue cinq gros deux ſcrupules de ſel marin á bâſe d'alkali, quarante á quarante ſept grains de ſel marin a bâſe terreuſe ou cathartique amer, et une petite quantité d'huile.

L'eau de pompe étant celle dont on fait un ûſage plus frequent, à fixé plus particulièrement mon attention; elle eſt plus ou moins chargée de parties hétérogênes conformement á ſa proximité avec la mer; ainſi celle des endroits bas eſt moins pûre que

* *Une pinte déau egalle au quart de* Boſton.

† *Le gros de ſoixante douze grains.*

proportion to its proximity to the waters of the ocean. That in low ſituations, is leſs pure than the water in more elevated grounds; it generally contains the ſame principles, except ſuch as have a ſuperabundance of calcareous earth. Among ſuch as I examined, the water of *Beacon-hill*, *Charter-Street*, and ſome in *New-Boſton*, appeared moſt free from impurities. The weight was generally from 15 to 40 grains above that of diſtilled water; the thermometer ſtanding in the open air at 32°, roſe to 40 and 46 on being immerſed, thoſe which contained the moſt impurities being warmeſt. Theſe waters have a brackiſh taſte to ſtrangers, and the inhabitants themſelves are ſenſible of it on drinking the purer element, which ſeems ſoft and inſipid; they are hard and do not diſſolve ſoap. I began with determining by the alkaline lixivium uſed in making Pruſſian blue, whether they contained any metallic principle; and being ſatisfied that they did not, I made the following experiments: I put into two ſeparate vials, equal parts of diſtilled water and of pump water, and having added to each an equal quantity of pulverized rhubarb,

que celle des lieux élevés, elle contient généralement partout les mêmes principes, éxcèptés quelques unes qui ſont ſur-chargées d'une quantité de terre calcaire; parmi celles que j'ai analiſées celle de *Beacon-Hill*, *Charter-Street*, et quelque une de *New-Boſton* m'ont paru les moins impûres. Leur poids eſt depuis quinze jus qu'à quarante grains par pinte plus péſante que l'eau diſtilleé, le thérmometre etant à l'air libre a trente deux, a monté à quarante et quarante cinq, par immerſion; celles qui contenoient le plus de parties hétérogènes etoient les plus chaudes.

Ces eaux ont un gout un peu ſaûmatre pour les etrangers, dont les habitans de *Boſton* s'apperçoivent quand ils en boivent de plus pûre la quelle ils trouvent fade et trop douce. Elles ſont dûres au toucher et ne diſſolvent pas le ſavon.

Je commencais d'abord par m'aſſurer au moyen de la leſſive alkaline pour le bleu de Pruſſe, de l'exiſtance ou non-éxiſtance d'une ſubſtance metallique quelconque; perſuadé qu'il n'y en avoit pas, je fis les expériences ſuivantes.

Je

rhubarb, I exposed them to the same degree of heat. The distilled water gave a fine yellow tincture, but in the other it was a deep yellow, inclining to red. The same experiment was made with cochineal, the one yielding a fine red, the other a deeper colour, verging to crimson, afterwards the colouring particles were precipitated, partly or intirely, according to the quantity of water. Logwood, instead of a lively, gave only a dull red, inclining to crimson; and with beet-juice the result was the same. Nutgalls gave out a tinge of their own colour in pure water, it was darker and more opaque in pump water, and a small addition of the fixed alkali turned it to a deep green.

These experiments seem already to indicate the nature of a salt with an earthy basis, having some marks of the marine acid. I poured upon a quantity of water, a solution of silver in the nitrous acid; there was immediately formed a white cloud, which soon after became pearl coloured, and then of a darkgrey; a solution of mercury, in the same menstruum, produced a cloud and white

Je mis separement dans deux bouteilles, parties égales de l'eau distillée et de l'eau de pompe, j'ajoutai dans chaque le même poids de rhubarbe en poudre, et les exposai au même degré de chaleur; l'eau distilleé a donné une teinture d'un beau jaune, tandis que l'autre a produit un jaune foncé tirant sur le rouge.

La même éxperience a été faite avec la cochenille, l'une a fourni un beau rouge, et l'autre a donné d'abord un rouge foncé qui aussitôt passa au cramoisi, ensuite la partie colorante a été precipiteé en grande partie, ou entiérement, selon la qualité de l'eau; le bois de campêche au lieu de fournir une teinture d'un beau rouge, a donné un rouge foncé et cramoisi. Le suc de bette rouge a produit le même éffet. La noix de galle a fourni une teinture de sa couleur dans l'eau pûre, elle a eté plus foncé et opâque avec l'eau de pompe, et bien peu d'alkali fixé la rendoit d'un vert foncé.

Ces experiences semblent déja indiquer la nature d'un sel á bâse terreuse, donnant quelques indices d'acide marin.

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white precipitate: a ſolution of the fixed alkali, or the alkali fluor, produced a white cloud, and the precipitate was about ſix grains to a pint; it diſſolved in acids with effervescence. Some of theſe waters (that of the cold bath in *Water-Street* for inſtance) being put into bottles, a quantity of air was perceived riſing in bubbles to the ſurface, and, by reſt, was entirely diſſipated, and then there might be diſcovered a ſmall ſediment. Lime-water dropped into theſe waters, formed a white cloud, and detached a precipitate of the ſame colour.

The water of *Beacon-hill*, and *Charter-Street*, gave no ſuch precipitate with the alkalies nor with lime-water.

Does not the precipitation formed by the lime-water, joined to the air-bubbles, and the ſediment taking place on their eſcape, indicate an earth ſuſpended by means of a ſuperabundance of air?

I proceeded next to evaporation; a pint gave from 10 to 36 grains of a ſaline earthy reſiduum, of a yellowiſh colour, which left

Je verſai ſur une quantité d'eau, quelques goûtes de diſſolution d'argent par l'acide nitreux, il ſe forma ſur le champ un nûage blanc qui bientot apres devint couleur de perle, et enſuite gris foncé; la diſſolution de mercure par le même acide donnoit un nûage et precipite blanc; une diſſolution d'alkali ſixe, ou l'alkali fluor faiſoit paroitre un nûage blanc et le précipité etoit d'environ ſix grains par pinte, il ſe diſſolvoit dans les acides avec efferveſcence; quelques unes des eaux tel que celle de *Water-Street*;* par exemple, miſes dans des bouteilles laiſſoient apperçevoir une grande quantité de bulles d'air qui montoient à la ſurface et ſe diſſipoient par le repôs; on apperçevoit alors un peu de ſediment, l'eau de chaux verſée goûte a goûte dans ces eaux, formoit un nuage blanc, et laiſſoit dépoſer un precipité de la même couleur; les eaux de *Beacon-Hill* et de *Charter-Street* ci devant mentionnées, ne flourniſſoient point ce precipite avec les alkali, ni avec l'eau de chaux.

Le precipité que forme l'eau de chaux joint aux bulles d'air que l'on apperçoit et au ſediment qui ſuit leur evaſion, ne ſemblent ils pas demontrer une terre ſuſpendue au moyen dune ſur abondance d'air?

Je

* *Cold Bath.*

left on the tongue a faltifh difagreeable tafte; thrown on a red-hot iron in the fire, there was no decrepitation; expofed to the air, it fwelled and grew white, attracting a little moifture.

A drachm and 12 grains of this refiduum diffolved in diftilled water, left on the filter 19 grains of a greyifh earth, which was in part foluble in the nitrous and marine acids, but lefs fo in the vitriolic, it was precipitated from the two former by the laft. Having evaporated the liquor to a pellicle, it gave no regular cryftals by cooling nor evaporation; a faline pellicle was formed on the liquor, which I broke to forward the cryftallization of what remained; this was of a yellowifh colour, and compleatly exficcated with great difficulty. This faline fubftance was neither acid nor alkaline, it left a faltifh impreffion on the tongue, and a copperifh tafte, decrepitated a little on the coals, and diffolved eafily in water. Fixed or volatile alkali added to this folution, caufed no fudden change, but a precipitation enfued foon after. Pouring upon this falt, the marine or nitrous acids,

Je procedai enfuite à l'evaporation, une pinte m'a fourni depuis dix jufqu'a trenté fix grains de réfidu falin terreux de couleur jaunatre, qui laiffoit fur la langue une impreffion faleé défagreeable, jetté fur un fer rougi au feu, ne décrepitoit pas, f'enfloit et blanchiffoit, expofé à lair il attiroit un peu l'humidité.

'Un gros et douze grains de ce réfidu, diffous dans l'eau diftilleé a laiffé fur le filtre dix-neuf grains de terre grifâtre, laquelle etoit en partie folùble dans les acides nitreux et marin, et le paroiffoit moins dans le vitriolique, elle etoit cépendant précipité des deux premiers par le dernier.

Ayant evaporé la liqueur jufqú à pellicule elle n'a point donnée de criftaux réguliers par le réfroidiffement, ni l'evaporation, une pellicule faline affez epaiffe f'eft formé fur la liqueur que j'ai rompu pour permettre la criftallifation du refte, qui ne f'eft faite que par deféchement et de couleur jaunâtre, difficile à fecher, cette fubftance faline n'etoit ni acide ni alkaline, elle laiffoit une impreffion falée fur la langue et un efpece de goút cùivreux, décrépitoit unpeu fur les charbons, fe

acids, no motion was excited; but the vitriolic raiſed a conſiderable fermentation, with vapours like thoſe where this acid is poured on dried ſea ſalt. This ſalt, expoſed to the air, attracted moiſture; but not ſo readily as that of which we ſhall preſently treat.

From theſe various experiments, may we not conclude that the waters of *Boſton* contain a ſea ſalt with a baſis of mineral alkali in ſmall quantity, a greater quantity of ſea ſalt with an earthy baſis, a certain quantity of oil, perhaps a little of *ſal catharticus amarus*.

There are beſides ſome which contain farther a ſuperabundance of earth, ſuſpended by means of an undue proportion of air.

To arrive at greater certainty, and make my experiments more deciſive, I combined ſea ſalt with an earthy baſis, by mixing powder of coral with the marine acid; the cryſtallization was

ſe diſſolvoit aiſement dans l'eau; l'alkali fixe ou volatile ajouté á cette diſſolution n'occaſionnoit pas de changement ſubit, mais quelque tems apres, un precipité; en verſant ſur ce ſel de l'acide marin ou nitreux il ne paroiſſoit aucun mouvement; mais ſi on ſe ſervoit du vitriolique, il éxcitoit une fermentation conſiderable, avec des vapeurs ſemblables á celles que ce même acide occaſionne lors qu'on le verſe ſur du ſel marin deſeché; ce ſel expoſé à lair attiroit l'humidité, çependant pas auſſi promptement que celui dont je parlerai ci apres.

D'apres ces diverſes experiences ne peut on pas conclure, que les eaux de *Boſton*, contiennent un ſel marin a bâſe d'alkali mineral en petite quantité, une plus grande de ſel marin a bâſe terreuſe, une certaine quantité d'hûile, peut être un peu de ſel cathartique amer.

En outre, il en eſt qui contiennent deplus une ſur abondante quantité de terre, laquelle m'a parue ſuſpendue au moyen d'une trop grande quantité d'air.

Pour m'aſſurer plus poſitivement et rendre mes experiences plus certaines, je combinai un ſel marin á bâſe terreuſe au moyen de la poudre de corail unie a l'acide marin,

like that of the preceding ſalt ; it was whiter, ariſing, I ſuppoſe, from a difference in the quantity of oil ; it more readily abſorbed moiſture, becauſe it was not combined with ſalt of an alkaline baſis, it did not decrepitate on the coals for the ſame reaſon ; in other reſpects, it exhibited the ſame appearances with the preceding ſalt.

Much remains to be ſaid, but time and circumſtances prevent my enlarging. If this ſketch ſhall be thought of utility, I ſhall be very agreeably recompenced.

marin, la criſtalliſation a été la même que celle du ſel precédent, mais il etoit plus blanc, cela depend, je crois, d'une difference hûileuſe, il attiroit plus promptement l'humidité de l'air par ce q'uil nétoit point mêlé de ſel à bâſe d'alkali, il ne décrepitoit point ſur les charbons par la même raiſon, au reſte, il preſentoit les mêmes phénomenes que le precedent.

Il reſte encore beaucoup des choſes a dire que le tems ni les circonſtances ne me permettent pas à preſent ; heureux ſi cet éſquiſſe peut etre ûtile, il devienda pour moi une recompenſe bien flatteuſe.

VIII. *Observations on the Longevity of the Inhabitants of* Ipswich *and* Hingham, *and Proposals for ascertaining the Value of Estates held for Life, and the Reversion of them. In a Letter from the Rev.* EDWARD WIGGLESWORTH, *F. A. A. and Hollisian Professor of Divinity in the University of* Cambridge, *to the Honourable* JAMES BOWDOIN, *Esq: Pres. A. A.*

Cambridge, *January* 28, 1782.

HON. SIR,

AFTER the last meeting of the Academy, the Rev. Mr. *Cutler*, of *Ipswich-Hamlet*, put into my hands a bill of the births and deaths in his parish, from September 11, 1771, to September 11, 1781. This bill has been kept with great accuracy; and it serves to shew, so far as a general conclusion can be drawn from the births and deaths in a single parish, that either the climate, or the manner of living on the sea-coast of *New-England*, is very favourable to life.

From the situation of *Breslaw*, and the employment of its inhabitants, Doctor *Halley* supposes that the deaths in that city are more proper for tracing out the probabilities of the continuance of the human life in its various stages, than those of any other large city in *Europe*. His table has accordingly been made the standard for estimating the value of those estates in *Great-Britain* which are held for life.

The Doctor observes, that the people of *Breslaw* are encreased by 1238 *births* annually. Of those it appears, by Dr. *Newman*'s tables, that 348 die *yearly*, in the first year of their age; so that but 890 do arrive at a full year's age; and that 193 die in five years, between one and six, complete;

so,

ſo that 692 of the perſons born, ſurvive ſix whole years, and but 710 ſurvive five whole years. Hence it follows, that at *Breſlaw* five perſons out of twelve that are born, die before they have completed the fifth year of their age. Whereas at *Ipſwich-Hamlet*, where, in the courſe of ten years, 331 perſons have been born, but 60 died before they had completed the fifth year; that is but 6 in 33; which determines *Ipſwich-Hamlet* to be more than twice as favourable as *Breſlaw*, for the preſervation of life in its firſt ſtages. A ſimilar concluſion may be made with reſpect to the late periods of life. For by Dr. *Halley's* table, out of 1000 perſons who die annually at *Breſlaw*, but 34 ſurvive 80 years complete. Whereas at *Ipſwich-Hamlet*, out of 164 perſons who have died in ten years, 21 perſons have ſurvived 80 years complete. At the former place, one in about 30; at the latter, one in about 8 arrive at this great age.

Mr. *Lincoln*, eldeſt ſon of the Hon. Major-General *Lincoln*, has been ſo kind as to favour me with a copy of the Rev. Mr. *Gay's* bills of the baptiſms, marriages and burials, in the firſt pariſh in *Hingham*, from 1726 to 1779, incluſive. This aged and venerable gentleman has been exceedingly accurate in keeping thoſe bills. The age of every perſon who has died in his pariſh for 54 years, is ſet down in the order of the deaths. This bill will be very ſerviceable in computing a table of the probabilities of the continuance of life in *New-England*, poſſibly more ſo than any others that can be obtained.

This bill I have reduced to the reſpective years of the human life, and by this means have determined the particular number that have died in each age. From the reduction, it appears, that *Hingham*, as well as *Ipſwich*, is more favourable to longe-

vity

vity than *Breſlaw*, the *Britiſh* ſtandard of life. At the firſt pariſh in *Hingham*, in a period of fifty-four years, 2247 perſons have been born; there have been 521 marriages, and 1113 deaths. Of thoſe, 168 have died in the firſt year, and 404 under five years complete. Out of 1113 perſons who have died in 54 years in that pariſh, 84 perſons have ſurvived 80 years complete; whereas at *Breſlaw* only 34 out of 1000 ſurvived that age.

Theſe ſpeculations are not deſigned as a *mere amuſement*; they are intended for *a valuable purpoſe in civil life*. The value of thoſe eſtates which are held for life, and the reverſion of them, can only be determined by knowing the probability which there is, that their reſpective holders will live for a longer or ſhorter term of years. Thoſe probabilities are different in different periods of life. The preſent value of two eſtates held in dower, whoſe annual incomes are equal, may be very different. For inſtance, a widow of 30 years of age has an equal chance of living, according to Dr. *Halley's* table, about 28 years; whereas one of 50 years has only an equal chance of living 17 years. The preſent value, therefore, of the eſtates held by them reſpectively, as well as the value of their reverſon, though their annual incomes ſhould be equal, are very different. There has, as yet, been no certain rule eſtabliſhed for eſtimating the value of ſuch eſtates. Whenever a widow has compounded with the heirs of an eſtate for a ſum of money in lieu of her dower, the compoſition has been made at random, and not on any fixed principles that have determined it to be equitable.

From the compariſon made above, it is evident, that the preſent value of eſtates among us, held for life, and the value of the reverſion of ſuch eſtates, cannot be traced with accuracy from

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the *European* tables. If ever it ſhould be effected, tables muſt be conſtructed among ourſelves; and this can only be done by keeping regular bills of mortality, comparing them together, and making proper deductions from their joint reſult.

It is therefore to be wiſhed, that thoſe gentlemen who have ſuch bills in their poſſeſſion, or have it in their power to procure them, would communicate them to the Academy at ſome future meeting.

I have incloſed the Rev. Mr. *Cutler's* bill, mentioned already, with a requeſt that I may be permitted to take a copy of it. Thoſe of the Rev. Mr. *Gay*, I have been prevented, by ill health, from putting into proper order for laying them before the Academy at their preſent meeting; but hope to be able to do it before the next meeting of the ſociety.

I am, &c.

EDWARD WIGGLESWORTH.

Honourable *James Bowdoin*, Eſquire.

END OF THE FIRST VOLUME.

E R R A T A.

Page.	Line.	
9	5	for *are*, read *is a*. l. 6, for *objects*, r. *object*.
10	6	from bot. for *of its pole*, r. *at its pole*.
13	4	after *altitude* put a (,) l. 27, for *ym*. r. *y*☽.
16	18	for *sum*, r. *sun*; l. 21, for *semi-diameter*, r. *semi-diameters*; l. 22, for *or moon*, r. *and moon*; in note * for *to her altitude*, r. *according to her altitude*; in note † for *disfraction*, r. *diffraction*.
19	22	after *ending* put a (,)
21	8	for *Mashelyne*, r. *Maskelyne*; l. 14. and passim, for *Winthorp*, r. *Winthrop*.
28	5	from bot. for *which give*, r. *which will give*; last line, for *B : C*. r. *B : b*.
29 } 30 }		in the calculations where the sine of D is called 9.6941970, alter it to 9.6941647, and where the sine of C. is called 9.9390986, alter it to 9.9391086.
30		last line, for *begun*, r. *began*.
36	3	from bot. for *semi-diameter*, r. *semi-diameters*.
48	2	from bot. for *fig*. I. read *fig*. V.
49	8	& 11, for *the ecliptic*, r. *the visible ecliptic*.
50	15	for 29° 6′ 49″ read 29° 46′ 49″
51		in the note, for 0″, 7, read 1,″ 7.
55	3	from bot. for 721,484, read 721,4.
	2	from bot. for 12′. 37,434, r. 12′. 1,4.
56	1	for ☿ *being retro*. r. ☿*'s motion being retro*.
62		last line, for *Sissons*, r. *Sisson*.
63	9	for 41° 24′ 30″, read 41° 24′ 18″.
	10	for 41 1 39 read 41 1 27
	11	for 40 39 3 read 40 38 51
63	16	& passim, for π read *eta*. §
77		in the column under III^h. and 40^m. and against Vs. + 5°, for 13″ 56‴, r. 12″ 56‴ immediately below, for 12″ 56‴, r. 13″ 41‴
79	7	for 12^h 3″ 43″ 30‴ r. 12^h 3′ 43″ 30‴
80	3	from bot. dele S. °. over ☉*'s long*.
87	8	for *Sissons*, read *Sisson*.
95	6	& passim, for *Dolland*, r. *Dollond*.
105	9	for *Lausbergius*, r. *Lansbergius*.
116	9	in the note, for *moime*, r. *moi-même*.
	20	for 29′ 10″, r. 29′ 19″.
120	17	for *My*, r. *By*; l. 21, for *result*, r. *results*; last line, for 12^h 5′ 57″, 33 r. 12^h 5′ 47″, 33.
124	8	for *by transmiting*, r. *the transmitting*.
	9	for *those*, r. *of those*.
127	1	for *mercury*, r. *the mercury*.
128	7	8, 9, 10, 11, 12, 13 & 14, for *set*, r. *setts*.
130	15	for 11h 58′ 16″, r. 11h 58′ 15″
146	12	for *intervals*, read *interval*.
151	7	for *began*, read *begun*.
156	9	for *these kind*, read *this kind*.
157	13	after *GFI*, insert *Plate* II. *fig*. VII.
	16	for *straight EF*, r. *straight line EF*.

Page.	Line.	
158	9	for *HB*=1299,5, read *HB*=1799,5.
	16	for 6° *ar*. read *Co. ar*.
162	20	for *Gasseudus*, r. *Gassendus*.
164	14	for *strove*, read *striven*.
166	3	for r^3+3re^2+3re, read $r^3+3r^2e+3re^2$.
	4	for $3re^2+3re^2$. read $3r^2e+3re^2$.
166	2	from bot. for 735, r. *to* 735.
170		at the bottom, r. *See note p*. 169.
173	14	for *division*, r. *divisor*.
174	2	dele comma after *parts*.
175		last word in the first sentence, r. *shilling*.
176	4	from bot. for *figure*, r. *figures*.
178		last column, against 18*s*. 11*d*. for 9449, r. 9459; and against £.1 0*s*. 0*d*. for 10000, read 1.0000.
179	4	from bot. for *retain*, r. *be retained*.
181	7	for *the figures*, r. *of the figures*.
210	10	for *time*, r. *times*.
	12	for *protentum*, r. *portentum*.
246	3	for *phenomena*, r. *phenomenon*.
254	5	for *effects*, read *effect*.
259	5	dele *not*.
262	4	for 1628, r. 1620.
270	14	for *northwesterly*, r. *southeasterly*.
275	6	from bot. for *circular*, r. *circuitous*.
	5	from bot. for *and*, read *from*.
285	18	dele *eight*; l. 20, for *twenty*, r. *twenty-eight*.
287		note, for 265 *and* 277, r. 269 *and* 276.
297	4	from bot. for *minerals*, r. *materials*.
303	19	for *phenomena*, read *phenomenon*.
309	13	for *adapted*, read *adopted*.
312	6	from bot. for *rods*, r. *yards*.
327	8	for *strice*, r. *striæ*, passim.
329	5	for *his*, r. *her*.
337	3	from bot. for *peripnumonys*, r. *peripneumonies* (some copies)
339	5	from bot. for *coldy*, r. *cloudy* (some copies)
345	8	from bot. for 77 (Noon.) 77 (P.M.), read 81 (Noon.) 74 (P.M.)
362	2	bot. for *corruscations*, r. *coruscations*. Passim.
363	2	bot. (note) for *Westford*, r. *Westfield*.
364	6	from bot. for *W*. r. N.
366	16	for *anginas tonsilaris*, r. *angina tonsillaris*.
383	19	for *weeds*, r. *a weed*.
392	10	for *genius*, r. *genus*.
417	14	for *roots*, r. *root*.
420	6	from bot. for *nautantibas*, r. *nutantibus*.
423	11	for *degitate*, r. *digitate*.
441	18	for *bushy*, r. *husky*.
454	21	for *inflammed*, r. *inflamed*.
455	6	after *plant*, r. 570.
	3	from bot. for *Hallow*, r. *Hollow*.
458	4	from bot. for *caulinus*, r. *caulinis*.

§ *The Printers, when this Table of Errata was struck off, were not possessed of the Greek Type, and were therefore obliged to express the Name of the Greek Letter, in English Characters.*

Page

E R R A T A.

Page.	Line.	
460	2 & 3,	for *corollaram-emerginata*, r. *corollarum-emarginata.*
	7	from bot. for *spiritous*, r. *spirituous*. Passim.
464	4	after *plant*, r. 660.
468	7	after *plant*, r. 735.
472	11	for *Orobus pinnatis*, r. *Orobus foliis pinnatis.*
481	15	for *Stanchbood*, r. *Stanchblood.*
484	16	for *tarter*, r. *tartar.*
486	22 & 23,	for CYRRIPEDIUM, r. CYPRIPEDIUM.
493	7	for *it*, r. *them*,
516	1	(note) for *Cowallo's*, r. *Cavallo's.*
527	5	from bot. for *tale*, r. *talc.*

Those few errors which are merely orthographical, and do not affect the sense, the reader is desired to correct for himself.

NOTE. Since Mr. *Cutler* communicated to the Academy the Meteorological Observations printed in this Volume, he has found, by a Course of Observations made with a new Barometer he has received from Mess'rs. *Nairne* and *Blunt*, that the Range of the Quicksilver in the Barometer he formerly used, must have been generally too high, by four-tenths of an Inch nearly.